Metallurgical and Chemical Engineering

Contents for August, 1915

The Coming Exposition of Chemical Industries

The curious individual who said that an exposition of chemical industries was a self-contradictory conception because chemical industries were secretive by nature, will find himself hopelessly behind the times when the National Exposition of Chemical Industries opens in New York City on Sept. 20. The commercial success of the exposition seems assured by the generous response of the industry and reversely great benefit can accrue from the exposition to the industry. As the exposition is primarily technical, it is an excellent idea to facilitate and insure the presence of chemists and engineers by arranging meetings of the various chemical societies in connection with the exhibition. In presenting in visible form—and wherever possible, in form of working models—the latest advances in machinery design, construction, and operation, the exposition can fulfill a distinct function of its own. It should be suggestive and encourage exchange of critical ideas and prove another connecting link between various classes of chemists and engineers.

More indirect, though by no means negligible will be the effect of the exposition on the industry by reason of the very fact that the general public will be largely attracted. To procure public recognition for chemistry, the public must be made to realize what chemistry is. No amount of lecturing will do this so well as a direct appeal to the senses. Chemical industry must be visualized by exhibits, working models, moving pictures. This is what the exposition will do. And the logical consequence will be a storage of appreciative good will that must be of immense value in future for the industry not only in connection with financial investments in the industry, but in connection with tariff and other legislation.

Bessemer and Open-Hearth Steel

Despite the astonishing increase in open-hearth steel making capacity in recent years, and a slight decrease in Bessemer steel making capacity, due to the abandonment of at least one large plant and the adaptation of some Bessemer blowing capacity to the duplex process, there is to-day what is described in steel market parlance as a "scarcity" of open-hearth steel. One can purchase Bessemer billets or sheet bars at a lower price than open-hearth billets or sheet bars. Buyers of finished steel who have exhibited a preference for open-hearth steel are in many cases being asked whether a substitution of Bessemer will be permitted. The trade reports state that practically the entire open-hearth capacity is in operation, but only 70 or 75 per cent of the Bessemer.

Sellers of steel insist that in many cases the prefer-

ence buyers express for open-hearth steel is not founded upon adequate knowledge, and that indeed there are numerous buyers who "would never know the difference" if Bessemer steel were substituted for open-hearth. Some sellers of steel actually wax impatient over the attitude of buyers in this connection, but it is in point to observe that in a measure the seller is himself responsible for the condition which now disturbs him. In periods of market dullness the seller who has both Bessemer and open-hearth steel to offer is quite prone to put the open-hearth in the front, thus fostering a habit on the part of the buyer to take open-hearth steel. The position of the seller at such a time has, perhaps, not been entirely altruistic. While we would not undertake to make an authoritative comparison, plant for plant, between the cost of making Bessemer and open-hearth steel respectively, it is a fact attested by the experience of numerous buyers that in the recent period of market stagnation they were able to buy open-hearth billets and sheet bars at a slightly lower average price than Bessemer steel of the same description, and the experience suggests that the maker who conducted both operations found the open-hearth process the cheaper. It may be unfortunate from the seller's standpoint that the buyer will not change his habits to suit the circumstances, but the preference expressed for open-hearth steel can hardly be described as a case of pure pig-headedness on the part of a buyer who would experience difficulty in distinguishing the one class of steel from the other. It can hardly be doubted that Bessemer steel could properly be used more widely than it is. In most cases of employment of merchant bars, pipe and wire no distinction is made, or could be made, by the ultimate consumer.

Patent Office Procedure

Elsewhere in this issue we publish a concise statement on United States patent procedure, viewed from the standpoint of a metallurgical engineer who wishes to remain anonymous though his name is well known from his connection with one of the most celebrated metallurgical patent suits of recent times. The statement is not only critical but constructive. Without committing this journal to every proposal made in the statement we may say that it presents admirably various phases of the situation that are well worthy of serious consideration. In the development of our patent law and practice the original object has been almost defeated. Our patent system was devised to foster the inventive genius; to give equal opportunity to all without regard to material wealth; to protect intellectual property among poor and rich alike.

Unfortunately our patent practice does not vest in the Patent Office the right or duty to pass finally on the validity of a patent when that validity is challenged after the patent is issued. That duty is left to our courts which, incidentally, are ill adapted to the work. The result is that an advantage is given to those who have the power of wealth to prosecute suits, while those less favored in this regard may find their rights abridged. Finally, the whole industry suffers

from the uncertainty of the outcome; progress is delayed and the public grows restless under a system which obviously works injustice.

The idea of publishing applications for patents so that all who believe their rights would be abridged by the granting of such patents may challenge their issue is a procedure that has simplified matters in the German Patent Office. If a challenge is offered, it need require only a brief hearing or a demonstration to enable the officials to decide whether the application shall be granted or denied. Such would be the function of the Patent Court suggested by our contributor.

The United States is prodigal in granting patent monopolies. Issued at the rate of about 100,000 per year at a cost for "maintenance and operation" of something like $25 per issue, it is obvious that a wholly inadequate sum is spent to enable the Patent Office to discharge its full duty to the public. Many of the patents granted are inconsequential, and others are in the nature of improvements that would naturally occur to the active mind of anyone engaged in a given line of industry. And yet each is a monopoly that can be made the basis of an injunction to restrain the holder of a like monopoly from exercising the presumptive rights which he obtained from the same source.

With the subject of patent practice receiving so much attention at the hands of competent and experienced thinkers, and with the public conscience quickened to the necessity of establishing conditions under which business and industry can develop normally and unhampered, the time should not be far distant when reform will be accomplished.

Engineering or Legal English?

From a power contract drawn by one of the large power companies at Niagara Falls:

"The word 'furnish,' when used in this agreement in reference to electric energy, is to be understood to mean readiness and ability . . . to furnish . . . electric energy at the agreed rate."

The Steel Industry and the War

The steel industry of the United States is now almost fully employed. Reports are that substantially all the open-hearth capacity is engaged, and 70 to 75 per cent of the Bessemer capacity, making an average for the industry of not far from 90 per cent. The condition is in striking contrast with that obtaining last December, when operations reached a particularly and unprecedentedly low ebb, at not more than about 35 per cent of capacity.

There is a disposition in some quarters to attribute the present steel-making activity, or at least a great part of it, to demand occasioned by the European war. Such a belief will hardly bear close investigation. It must be recognized, in the first place, that the breaking out of the war caused a great decrease in industrial activity in the United States, while as conditions became better understood there was a reaction. A part of the demand for steel that has been experienced since

Jan. 1 represents simply demand that ought to have been expressed in the closing months of 1914. The fact is worthy of consideration in this connection that an improvement in the steel market occurred in June and July, 1914, and that at the time many reputable observers expressed strong hopes that the improvement then noted represented the beginning of a general movement toward real prosperity. The breaking out of the war suddenly arrested this improvement, but it does not follow that the movement could not be resumed at a later time.

A great deal of the present demand for steel can be traced to ordinary domestic consumers. Freight car orders definitely placed after the war started, and up to the beginning of last May, made a total of only 15,000. In the past three months railroads in the United States have placed orders for about 35,000 freight cars, representing a rate seven times as great. In the three months the French and Russian governments have placed orders in the United States for 21,000 cars. These may be regarded as war orders, but they represent only 30 per cent of the total freight-car buying since the war started. As another illustration of domestic demand it may be noted that while the American motor-car industry has been stimulated by war orders, it is well known that the deliveries of cars to domestic buyers during the season just ended have broken all records, and the automobile industry is entering a new season in expectation of a still larger demand. The export demand may be important, but the domestic demand is in itself making an excellent record. As another illustration it may be mentioned that in April and May, as the agricultural implement industry reached the close of its regular manufacturing season, it was found that the production had been less than it should have been. There was a speeding up at the last moment, and the intention is to make a much larger output in the season now being entered upon. The case of the agricultural implement trade is of particular interest, because it has suffered very seriously in the export direction, the exports in the last fiscal year having been less than one-third as heavy as in the preceding fiscal year.

Illustrations of this sort could be multiplied, showing in detail that the domestic demand for steel has very materially increased. The export movement it is necessary to discuss under two heads, the exports to belligerents and the exports to neutrals. The exports to belligerents, again, must be subdivided into two classes, material required for war purposes, and material required because former sources of supply are shut off. British imports of blooms, billets, sheet bars and wire rods from the United States, according to the June returns of the Board of Trade, are at the rate of over 650,000 tons a year. In chief part this movement represents the shutting off of imports hitherto drawn from Belgium and Germany, but the total imports are somewhat larger than they were a year ago. There are other exports of this character to belligerents, including wire rods to France, nails to both England and France, and scrap and pig iron to Italy.

Of the exports of regular steel-mill products to belligerents only a relatively small proportion can be distinguished as intended for war purposes. By far the largest items are steel bars for the manufacture of shells, and barb wire. In May we exported of the former 37,260 tons and of the latter 18,182 tons, and some portion at least of the tonnage went to neutral countries, but even the total tonnage represents but a trifle more than 2 per cent of our steel-making capacity. As to the steel involved in shells which are manufactured in this country and then exported there are no statistics, but it is evident that the tonnage cannot be more than a very few per cent of our total steel output.

The war would throw a very large tonnage of steel demand from neutral countries to the United States, if the demand existed, but unfortunately no large demand has thus far developed. During three or four years prior to the war the combined exports of the great iron and steel exporting countries, Germany, England, the United States, and Belgium, named in the order of their importance, and excluding exports to each other, averaged very nearly if not quite 10,000,000 tons a year. The only exporting countries now are England and the United States. The British exports to neutral and non-producing countries are now at the rate of about 2,500,000 tons a year, while the similar exports of the United States may be estimated at not more than 1,500,000 tons, making total exports to neutral and non-producing countries of not to exceed 4,000,000 tons, when formerly there was demand for 10,000,000 tons. It must now be mentioned that we include in the British exports just mentioned the exports to India and British colonies, and these exports really amount to fully one-half of the total. There is reason to believe that if the demand increases over the rate of 4,000,000 tons the lion's share of the increase will fall to the United States, since Great Britain does not seem to be in position to accept more business. That is for the future, but there are much greater prospects of our export trade increasing in this direction than of its increasing in the matter of war material. The possible demand from neutral countries covers practically all classes of steel products, while the demand from the belligerents is confined largely to relatively few commodities.

While only rough estimates can be made, it would appear that while our steel exports to neutral countries are at the rate of about 1,500,000 tons a year, our exports to the belligerents of steel in all forms, including that used in the manufacture of shells, motor trucks, railroad rolling stock, etc., do not exceed 2,000,000 tons, or possibly 2,500,000 tons at the very outside. Inasmuch as the present finished steel capacity is in the neighborhood of 27,000,000 or 28,000,000 tons a year, our actual production being at the rate of nearly 25,000,000 tons a year, it is evident that our total steel exports, even including the exports to neutral countries, do not account for any very large part of the present manufacturing activity. The actual consumption of steel in the United States is by far the chief cause of the steel trade's prosperity.

Readers' Views and Comments

Needed Changes in the Patent System

To the Editor of Metallurgical & Chemical Engineering:

SIR:—The experience of our nation with business monopolies has been such as to lead us to place, through our legislative bodies, certain restraints upon the forms and operation of monopolistic enterprises. While we have been following out this policy, endeavoring to re-establish the conditions under which business can have its most normal development, we have overlooked the fact that our Government is annually, through the machinery of the Patent Office, creating thousands of ill-defined monopolies over which no control is retained by the Government, and which are so created that they are in many instances a decided handicap to the development of industry.

The fundamental assumption upon which patents are issued is that the granting of a temporary monopoly in the control of an improved process or apparatus will stimulate the work of invention and the development of new processes and forms of apparatus by making it possible for the inventor to get an adequate profit through the temporary monopoly of his invention, and that the public will profit by this system through the increase in improved processes and apparatus, and the final free use of the same as divulged in the Letters Patent which are granted to the inventor.

NATURAL EVOLUTION OF ARTS AND INDUSTRIES

The development of any art or industry is a gradual evolution, each step of which is made possible by work which has been done before, and each step, in advance of which is, to a considerable extent a natural evolution of what has preceded it. Innumerable instances of practically simultaneous inventions of processes or apparatus, and of practically simultaneous discovery of scientific truths, have demonstrated that many, if not most, of the advances in industry and science would be made by one individual if not by another, because the development of the art or science has brought it to such a state that the next steps to be taken are so much a matter of necessity that they will be taken by any one of a number of those who are confronted with a problem.

It has been a commonly accepted belief that invention partakes somewhat of the nature of inspiration; but a study of the history of the development of any of our arts will show that a great part of the steps forward which have been made, have been the logical result of that which has been done before, and have not involved any high degree of inventive ingenuity or any long period of research. There are, however, many new processes and forms of apparatus which are the result of the application of highly developed inventive capacity to the solution of difficult problems through long and expensive periods of research work.

A patent is a monopoly granted in derogation of one of the most fundamental and valuable rights of mankind, the right of each individual to use for his own profit all of the information which he may possess. This right is of such vast importance that if it is abridged the greatest care should be used to protect, not only the inventor whose work is to be stimulated by the patent system, but the rights of the public, which are definitely restricted by every patent which is granted.

The law, as now enacted and administered, places unnecessary obstacles in the way of the development of industry, as the Patent Office, the chief function of which is to determine whether or not inventors are entitled to patents for their alleged inventions, does not finally determine that matter. A United States patent is not considered to have any established validity until it has been made the subject of litigation which has passed through all of our courts up to the highest tribunal of the land. No technical expert nor legal adviser nor body of experts or advisers can foretell what the courts will consider a patent to cover; or whether or not, on being made a matter of contest, a patent will be held to be valid. To determine the scope of a patent, and whether or not it is valid, requires a contest extending through several years' time and involving enormous expenses. Thomas A. Edison is credited with the statement that an American patent is nothing more than an introduction to the United States Supreme Court. This is practically true, and anyone who has had occasion to be introduced to that exclusive body will realize that the introduction involves a degree of expense which cannot be borne by the type of men who actually advance industry by their inventions.

The effect of this method of dealing with patents is to greatly discourage inventors; to seriously handicap or debar those who have inventive capacity from its profitable employment; to delay the adoption of inventions of proven merit, and to generally and unnecessarily interfere with the development of industry.

SUGGESTION FOR GREATER PATENT OFFICE

The whole subject of the validity of patents and patent rights should be dealt with by one compact organization, which could well be built around our present Patent Office. All matters dealing with the granting of patents, the status and control of patents, and the litigation relating to patents should fall within the province of this greater Patent Office.

This office could well consist of three departments: a department attending to those matters concerned with the granting of patents; a permanent patent court, before the branches of which all patent litigation should be disposed of; and a department or commission having power to establish the conditions under which monopolies resulting from the granting of patents shall be exercised.

The Patent Office should be more adequately housed than it is at the present time, and adequate provision should be made for all of its activities. The library should be made absolutely complete, and its contents should be made easily available for all of the needs of the Patent Office staff, and for such of the public as choose to make use of it. Laboratories should be provided in which the inventor should be made to demonstrate the proven workability of his invention, if it be demonstrable without large or elaborate installations. These laboratories should also be available for the demonstrations necessary in illustrating the inventions involved in patent litigation.

The patent law and practice should be so modified that every application for patent should be published, and that opportunity should be given to all who consider that they possess rights which will be abridged by the granting of this patent to set forth their rights through simple and expeditious procedure, accompanied by an absolute minimum of red tape.

As previously stated, no patent should be granted for

anything but a complete and workable invention; and no patent should be granted for improvements which must be the natural outcome of the application of reasonable engineering ability and skill to the solution of engineering problems. A patent should be made much more difficult to obtain, but much more easy to defend when once obtained.

All litigation relating to the validity of patents should be heard by special courts forming an integral part of the Patent Office. These courts should be given discretionary power as to what issues should be heard before them, and what evidence should be entertained, so that it should be impossible for patents and the patent courts to be made a means by which inventors or the public could be unnecessarily harassed.

It should be possible for anyone to institute proceedings to determine the validity of a patent, so that this matter might be determined without the necessity of first infringing the alleged rights of the patent and running the possible risk of being assessed damages for such infringement.

All litigation relating to the validity of patents should be heard before courts consisting of at least two members of the Patent Office's regular judicial staff, who, by training and experience, are particularly conversant with the branch of industry to which the patent litigation pertains, sitting with at least one other member of the regular judicial staff of the Patent Office who has had special training and experience in the patent law.

ADJUDICATION WITHOUT APPEAL

It appears to a layman that there should be no possibility of appeal from the decision of this court. The whole theory of appeal involves the assumption that it is possible, when a case has been once passed upon by a court, to find a more competent court to hear it again, and so on through the series of courts to which appeal may be taken. No court which is not competent to give a final decision upon a case should be allowed to try it at all; and when the court which is competent to give a decision in the case has once passed upon it, that case and the issues involved therein should be forever closed.

If this assumption is not well taken, and it is necessary to provide for the possibility of appeal of cases from the court of first instance, it could be provided that a court of appeal, also a regular part of the Patent Office, and constituted of experts in technical matters and patent law, should have power to order, upon proper showing of necessity for doing so, a review of questions involving the interpretation of patent law, by a court consisting of all the regular law judges of the department sitting en banc, from whose decision no further appeal could be taken, and which could also under conditions warranting such action, provide for the review of questions of fact before judges especially selected by it from the regular judicial staff, whose decision should be final. But special stress should be laid by the law upon the fact that great injustice is done by delay in disposing of patent litigation.

All procedure before the patent courts should be so simple that the poorest inventor could, if necessary, defend his own case unaided. When advisable, sections of the patent courts should hold their hearings in other cities than Washington, D. C.

As it is possible for the owner of a patent to place unnecessary obstacles in the way of the development of arts and industries, by withholding improved processes or apparatus from use; by making extortionate charges for the use of patented processes or apparatus, or by monopolizing improvements perfected by others, as a consequence of possessing earlier patents covering imperfected inventions, provision should be made for revoking patents not put to successful use within a reasonable length of time, and for determining the charges that may be made for use of patented inventions and the types of contracts under which they may be disposed of.

TAXATION OF PATENTS

Several foreign governments regularly tax patents. It is probable that public interest would be served if our Government should charge an annual license fee for every patent for each year of its life after two years from the date of issue, and forfeit all patents for which this annual fee is not promptly paid.

If it is impossible, during the first two or three years after a patent is granted, to establish its value to such an extent that the inventor can afford to pay an annual license fee or tax to keep his rights alive, the patent should be allowed to lapse and the rights of the public should be no longer abridged by it.

These annual fees would not have to be large to furnish adequate funds to support the organization herein outlined and provide ample revenue so that such salaries could be paid as to command and retain the services of the ablest type of men.

The judicial staff should be so large that all matters coming before it should be finally disposed of within six months at the most from the time actions are commenced.

Long periods of uncertainty as to the rights of the inventor and the public are so prejudicial to the development of industry that they should not be tolerated by a business-like nation. Public business should be dispatched with the promptness and thoroughness demanded in private business.

If the modifications of law and practice herein suggested should be adopted, all of the rights of the inventor and of the public could be adequately protected; invention would be stimulated, as inventors would realize that if their inventions were truly patentable, they would obtain patents therefor which could be cheaply defended; and progress in the development of the arts and industries would not be retarded through the great expense and long periods of waiting now required to determine whether or not patents which have been granted by the United States Government convey any defendable rights..

AN ENGINEER.

A Modified Iron-Carbon Diagram

To the Editor of Metallurgical & Chemical Engineering:

SIR:—In my work with the Chinese students during the past four years a constant effort has been necessary to simplify and clarify problems, especially of a practical nature, owing to the fact that the Chinese methods of education in the past have not been given to practical lines but more to the training of the memory.

Further, when we consider the fact that the peculiarly rigid and inelastic form of the language does not allow of its being readily adapted to technical expressions or terms, and that the student has first to learn a foreign language which is fundamentally different from his own, both in methods of writing, construction and expression, it stands to reason that not only is it necessary to use the simplest expressions and clearest explanations possible, but also carefully to avoid the least possibility of confusion in the presentation of ideas or practical facts.

Among other things we have, for instance, the study of metallography in relation to the alloys, more especially that of iron-carbon, in the study of the metallurgy of iron and steel.

Of course, we all know that there are some very mate-

rial differences between authorities regarding some of the points included in the equilibrium diagram and some of them have led to rather puzzling questions from the students.

As we endeavor to make our work on iron and steel as thorough as possible it became quite necessary to take up these differences and if possible, to harmonize them so as to relieve the minds of the students of any confusion or distrust as to accuracy.

The text books used are Stoughton's "Metallurgy of Iron and Steel," and Hofman's "General Metallurgy," with references to Sauveur's "Metallography of Iron and Steel," Howe's "Iron, Steel and Other Alloys," and Tiemann's "Iron and Steel" for definitions.

A metallographic laboratory has recently been equipped with apparatus for grinding, polishing, etching and photographing as well as for recording recalescence curves for the better study of metallography in general as well as in special work.

As Sauveur is taken as a guide in the metallography, and Stoughton as a text book in the metallurgy of iron and steel, I soon came up against these disagreements of statements and it became necessary to harmonize them, as stated before, or to leave one authority discredited.

BOUNDARY BETWEEN CAST IRON AND STEEL

The first point to be considered was that of the location of the boundary line between steels and cast iron.

On page 6 of Stoughton, second edition, 1911, he says,

FIG. 1—MODIFIED IRON-CARBON DIAGRAM

"Cast iron generically is iron containing so much carbon or its equivalent that it is not malleable at any temperature. * * * The committee[1] recommends drawing the line between cast iron and steel at 2.20 per cent carbon for the reason that this appears from the results of Carpenter and Keeling to be the critical percentage of carbon corresponding to point *a* in the diagrams of Roberts-Austen and Roozeboom."

Again (*ibid.*), "It is because of this difference in the freezing of the alloys that the line *XY* (at 2.2 per cent) is arbitrarily considered as the dividing line between steel and cast iron."

Howe, in his "Iron, Steel and Other Alloys," second edition, 1906, page 170, says, "Fortunately there is one criterion which may be adopted for discriminating between all the various classes of steel on one hand and those of cast iron on the other, a criterion which we may apply to all future varieties of iron when we seek to decide whether they ought to be called steel or cast iron.

[1]Committee on the Uniform Nomenclature of Iron and Steel of the International Association for Testing Materials.

This criterion is malleableness in at least some one range of temperature; we may adopt it because such malleableness is probably the only important specific property which all steels of to-day have and all cast irons of to-day lack, if we except the special product known as 'malleable cast iron.' * * * Cast iron, iron containing so much carbon or its equivalent as not to be malleable at any temperature, * * * the dividing line between steel and cast iron may, for the present, be put arbitrarily at 2 per cent of carbon." Again (*ibid.*) on page 195, "In this work the dividing line between cast iron and steel has been arbitrarily drawn at 2 per cent of carbon, in rough accordance with commercial usage."

Sauveur, in his "Metallography of Iron and Steel," first edition, 1912, Lesson XIX, pages 5-6-8, says, "It will be evident that, starting from carbonless iron, as the carbon increases, at first low-carbon steel is produced and then in succession medium high-carbon steel, high-carbon steel and finally white cast iron, each metal passing gradually into the next without any sharp line of demarcation between them. It is logical to base the distinction between high-carbon steel and white cast iron upon the malleability of the former and the non-malleability of the latter and this is altogether a question of carbon content. The dividing line may be drawn somewhat arbitrarily at 2 per cent carbon. *As a matter of fact steels are very seldom manufactured containing more than 1.75 per cent carbon while white cast iron rarely contains less than 2.25 per cent carbon. Between the steel series, therefore, and the white cast-iron series there is a natural gap, the existence of which generally removes any doubt as to the nature of the metal under examination.* Again if the process of manufacture be known there need be no doubt as to the classification of any highly carburized iron alloy; if made in the blast furnace from the reduction of iron ore, it is cast iron, while if it is the product of refining cast iron, * * * or of the remelting under oxidizing conditions of iron or steel scrap, with or without cast iron, * * * or of the carburizing of wrought iron, * * * or of the carburizing and melting of wrought iron, it is steel. * * *

"The portions of the diagram corresponding respectively to the steel series and to the cast-iron series have also been indicated, leaving two groups of alloys unrepresented by industrial products, namely, those containing between 1.70 per cent and 2.25 per cent carbon and those containing more than 5 per cent carbon. * * * (Footnote:) Again some unimportant products are offered for sale under the name of semisteel which may contain between 1.75 and 2.5 per cent of total carbon entirely combined, forming, therefore, a sort of connecting link between the steel and the cast-iron series. They are frequently obtained by remelting cast iron in cupola furnaces in the presence of considerable iron or steel scrap. Washed metal likewise may contain between 1.75 and 2.5 per cent of total carbon entirely combined, but this is a semi-finished product resulting from a partial refining only of cast iron."

Tiemann, in his "Iron and Steel," first edition, 1910, on page 44, under "Cast Iron," says, "It contains a considerable proportion of carbon (say 2.2 per cent) up to about 7 per cent—usually from about 2.5 to 4 per cent, and variable percentages of other substances, such as silicon, manganese, phosphorus, sulphur, etc. It is hard and brittle and cannot be rolled or forged at any temperature." And again on page 318 under "Steel," "That form of iron produced in a fluid condition and hence practically free from slag (difference from wrought iron) which contains less than about 2.2 per cent of carbon—as a rule less than 1.5 per cent (difference from cast iron)."

Now comparing the above there must be some rea-

sonable explanation for this rather broad difference and in reading the quotation from Sauveur it is very fair to assume that he has met the point especially where he says, on page 5 of Lesson XIX, "As a matter of fact steels are very seldom manufactured containing more than 1.75 per cent carbon, etc.," quoted above.

From this it can be assumed that the circumstances under which the product is made will govern the character, i.e., under some conditions it will meet the definition for steel taken from the report of March 31, 1906, of the Committee on the Uniform Nomenclature of Iron and Steel as quoted above, and under some other conditions of manufacture will meet the definition for cast iron, even though the carbon content may be the same, and that all combined.

As a result I have drawn the lines A-S in Fig. 1, so as to cover the zone between these two amounts and have called it "The Zone of Merging." This extends from 1.7 per cent on the one extreme to 2.2 per cent on the other, with an intermediate line at 2 per cent as an average.

LOCATION OF EUTECTOID LINE

The next point was that of the location of the eutectoid line. Stoughton, on page 292, under "Eutectoid," says, "The alloy containing 0.9 per cent carbon is known as the 'eutectoid alloy'." Again, on page 303 (ibid.), "The practiced eye can usually tell; but a chemical analysis readily distinguishes, since steel with less than 0.8 per cent carbon will have excess ferrite, and that with more than 0.9 per cent will have excess cementite."

Sauveur, in Lesson V, page 4, under "High-Carbon Steel," says, "Since the introduction of increasing amounts of carbon in steel results in the formation of a correspondingly increasing proportion of pearlite and a decreasing proportion of ferrite, a degree of carburization must necessarily be reached, when the whole mass will be made up of pearlite, the ferrite having finally disappeared. This critical point in the structure of steel is attained when *the metal contains somewhere between 0.8 and 0.9 per cent of carbon, exceptionally pure steel requiring the larger proportion of carbon and impure steel the smaller for the complete disappearance of ferrite.*"

Again (ibid.), on the same page, under "Eutectoid Steel," "Steel containing less than 0.85 per cent of carbon, *or thereabout,* and in which, therefore, some free ferrite is present, is called 'hypo-eutectoid,' while steel more highly carburized than eutectoid steel is called 'hyper-eutectoid'." Again (ibid.), on page 9 of the same lesson, he demonstrates the theoretical percentage of carbon in "pearlite" as being 0.834.

Tiemann, on page 185, under "Pearlite," says, "A eutectoid of cementite and crystallized iron formed by slow cooling past Ar_1. * * * It should be regarded as a variable mixture, for in structural steels containing between 0.5 and 1 per cent manganese, the carbon in pearlite varies between 0.6 and 0.9 per cent, and in some tool steels, according to the method of treatment, the pearlite accompanied by free cementite may contain 1 per cent carbon."

From these authorities we may assume that the eutectoid, depending on varying conditions, may ordinarily lie anywhere between 0.8 and 0.9 per cent carbon and have a general average of 0.85 per cent in accordance with the statement of Professor Sauveur. This I have assumed in my diagram, making the eutectoid area extend from 0.8 to 0.9 per cent, in accordance with the above.

The liquidus line from L to E has been assumed as being slightly curved, following Carpenter and Keeling's equilibrium diagram shown on page 18 of Lesson XXIII of Sauveur.

The solidus line from L to A has been made in accordance with Rosenhain, as explained on page 20 of Lesson XXIII of Sauveur.

A limiting line has been placed at 5 per cent carbon as the limit of carbon usually in commercial irons, according to Sauveur's statement from page 8 of Lesson XIX as quoted above, from the fact that these irons seldom carry more than 5 per cent carbon. Those carrying more than this amount I have designated as supercarbon irons, in order to have some distinguishing term.

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The Western Metallurgical Field

Two Historical Notes on Flotation

With the rapidly increasing use of the oil-flotation process of concentration, and the consequent investigation of various processes and search of the literature on the subject, it is interesting to note some of the earlier work. It will be found true in many instances that various investigators observed certain effects that are now well known, but which may have been passed over at the time without a full realization of their value and importance.

Flotation by means of a stiff froth produced by violent agitation of an ore pulp to which oil has been added, is now one of the most common forms of the process. An interesting early reference* to the froth or foam effect is to be found in the *California Journal of Technology* for November, 1903, in an article by Messrs. W. F. Copeland, Drury Butler and James H. Wise. The authors presented some experiments on the Elmore process of oil concentration, which at that time was comparatively new. After describing their experimental work on a variety of ores, they close the article with this interesting reference:

"**Foam Effect.**—The foam effect is produced by a violent agitation, especially in acid or salt solutions. This throws the oil into a froth, which is heavily charged with air or other gases. This gas, of course, gives a greatly increased buoyant force. The oil in this condition assumes a certain load of mineral and holds it in a very stable condition. The charge does not settle and overload on standing as in the case of the lake effect. The foam effect is best adapted for light, flaky minerals, such as molybdenite."

In contrast to the stiff froth or foam formed by violent agitation, there has come into prominence more recently a process making use of a light and less coherent froth, produced by the introduction of air or gas through a porous medium; so that it enters the pulp in a finely divided condition. This effects a gaseous flotation of mineral particles. The froth thus produced breaks down more readily than some of the stiffer froths produced by violent mechanical agitation, and this feature is an advantage in many respects, particularly when the floated concentrate contains two minerals, say lead and zinc sulphides, which are to be separated on tables.

The principles of this method were described by T. J. Hoover and Minerals Separation, Ltd., when in 1910 they secured British patent No. 10,929, based on this method of flotation. But as far as known they did not secure patent in the United States. A quotation from the specification is instructive.

"According to this invention the method of introducing air or other gas into an ore pulp for the purpose of effecting flotation of certain particles consists in bringing the ore pulp into contact with a porous medium

*Compare also the report on the flotation suit in July issue, page 409.

through which air or other gas is caused to pass. Thus according to one method the pulp is introduced into a vessel having one or more porous walls through which air or other gas can be caused to pass.

"The porous media employed according to this invention may consist of plates of porous ceramic material, porous bricks, coke, or felt or other fibrous material suitably supported.

"The gas which is caused to pass through the porous medium into the ore pulp may be air or furnace gases, or it may be a gas produced chemically such as carbonic acid liberated from a carbonate or the gas may be produced electrolytically, or the gas which is passed through the porous medium may act both as selective agent and as frothing agent; a gas such as formaldehyde or carbon bisulphide vapor can be thus employed. The introduction of the gas through the porous medium may be effected either by pressure or by suction."

Metallurgy of Low-Grade and Complex Ores of Utah

In spite of the wonderful advance made in handling economically the low-grade and complex ores of Utah, as instanced by the work of the Utah Copper Company and others, a varied problem still remains to be solved. Utah's eminence as a mining State lies mainly in her large supply of low and medium-grade ores, some of which are quite complex and require careful metallurgical treatment. Fortunately the problem is being attacked in a systematic manner by a co-operative arrangement between the University of Utah and the U. S. Bureau of Mines. A preliminary report on the situation is embodied in Technical paper No. 90 of the Bureau of Mines, by Messrs. Lyon, Bradford, Arentz, Ralston and Larson. A careful survey of the mineral resources of the State has been made, resulting in a classification of the various types of ores. Some of these are being treated, but not in the most economic manner. Suggestions are made for improvements in treatment that will return a larger net profit to the owner.

Among processes having a possible application to Utah ores, the following are mentioned: For lead carbonates carrying silver; the Murex process, combining oil selection and magnetic separation; sulphidizing and flotation, converting the oxidized minerals to sulphides by hydrogen sulphide and then floating; electrostatic separation, after first coating the particles by the sulphidizing process.

For oxidized copper ores carrying gold and silver: Chloridizing and leaching; sulphidizing and flotation; leaching with ammonia-cyanide solution, according to the Mosher-Ludlow process; leaching with hypochlorous acid, according to the Slater process.

For oxidized zinc ores, occasionally carrying gold and silver: Igneous concentration, producing zinc oxide for pigment or further reduction; leaching with ammonium carbonate solution; leaching with sulphur dioxide solution, as proposed and tested at Swansea, Wales; leaching with acid solution, and electrolytic precipitation of zinc.

For oxidized zinc-lead ores, occasionally carrying gold and silver: The bisulphite process just mentioned, dissolving the zinc and smelting the lead residue; leaching with ammonium carbonate solution; sulphidizing and flotation, separating lead from zinc, the latter not being affected.

For oxidized ores of zinc and copper, carrying gold and silver: Leaching with ammonium carbonate solution and separating by electrolysis; the bisulphite process; leaching with acid solution and electrolytic precipitation; igneous concentration, recovering zinc oxide and smelting the copper residue.

Utah has an abundant supply of raw materials that can serve as reagents for carrying on many of these processes. An unlimited supply of salt is at hand, associated with mirabilite (Na_2SO_4), from which numerous reagents can be prepared. Sulphuric acid could be produced at smelting plants, and sponge iron for use as a precipitant can be prepared from many iron ores in the State. Coal and coke are readily obtained, and acid-resisting hydrocarbons for vat lining exist in large quantities. In short the State offers a wonderful field for the investigation of the problem that has been so ably presented in the preliminary report.

Workmen's Compensation Insurance in Colorado

Since the adoption of workmen's compensation insurance in Colorado at the last general election, the State industrial commission has been engaged in settling premium rates for various lines of industry. The rates that should apply to the mining and metallurgical industries have been the subject of much concern, for it was felt that such rates might easily be made oppressive, inasmuch as the mining industry cannot add the cost of such insurance to the price of metals and thus distribute the burden among consumers. Rates have now been settled, however, and the industrial commission has notified private insurance companies that it will approve the following premium rates per $100 of payroll: For underground employees in metalliferous mines, $3.75; for surface workers at mines of the same class, $2.39. Where employers supply medical and hospital service in accordance with the law, 25 per cent of the rate will be cut off. Previous to the action by the industrial commission, private companies had filed an average rate of $3.85 per $100 of payroll. The rates approved by the industrial commission will probably induce most mining companies to take their compensation insurance with the State fund. In the case of coal companies a rate of $6 per $100 of payroll has been approved. The larger coal companies may form a mutual insurance company to carry their compensation insurance.

Increased Valuation of Joplin Output

According to the Joplin *News-Herald* the value of zinc and lead ores produced and shipped from the Joplin district for the first half of 1915 is $11,303,654, as compared with $7,620,268 for the first half of 1912, which was the previous banner year. The aggregate production for 1912 was valued at $18,043,379, but this will be exceeded this year if the mean weekly valuation reaches $260,000. Of late the weekly valuation has been averaging $500,000, so that from present indications the value for 1915 will break all records. Comparative figures for the first half years 1912 and 1915 are given below:

	Shipments		Values	
	1912. Lb.	1915. Lb.	1912.	1915.
Blende	253,681,839	276,290,830	$6,203,554	$9,772,546
Calamine	16,016,160	22,470,472	241,678	479,964
Lead	51,993,604	42,753,990	1,175,036	1,101,144

Company Reports

The ninth annual report of the **Buffalo Mines, Ltd.,** Cobalt, Ontario, Canada, covers the yearly period ended April 30, 1915. The low price of silver, the high cost of supplies and the shortage of power combined to make unfavorable conditions for production and marketing during this period. The concentrating mill and cyanide plant were closed for four months, and subsequent operations were on three-fourths time, so that the report really covers little more than six months' production. The financial statement shows net income of $79,690. A dividend of $50,000 was paid. The total surplus is

$379,968. The concentrating mill treated 51,667 tons of ore averaging 19.5 oz. silver. The recovery by concentration was 72.22 per cent. The cyanide plant treated 8385 tons of slime averaging 9.86 oz. silver, recovering 82.26 per cent. The amalgamation plant and refinery treated 4925 lb. of high-grade ore, 163,865 lb. of jig concentrate, 547,010 lb. of table concentrate and 3600 lb. of metallics from the low-grade mill, and 11,967 lb. of precipitate from the cyanide mill, all containing 409,525 oz. of silver. The total recovery from the plant was 442,299 oz. silver, the excess being process silver from ores previously treated. The total production for the year was 822,791 oz. of silver. Ore reserves are estimated at 42,000 tons that will average 20 oz. per ton. The plant for cyaniding sand tailing has not been built as present conditions do not warrant the expenditure. Recovery of mercury from the amalgamation residues amounted to 41,850 lb.

The annual report of the **McKinley-Darragh-Savage Mines,** Cobalt, Ontario, Canada, for the year 1914, shows a production of 1,396,540 oz. of silver, of which 1,159,154 oz. came from the McKinley and the balance from the Savage. The total silver shipped to Jan. 1, 1915, from these mines is 14,123,525 oz. Ore reserves are estimated at 68,011 tons, containing 2,132,820 oz. of silver. A brief statement of milling operations is given below.

	Tons treated	Oz. silver per ton	Oz. silver per ton tailings	Percentage extraction
McKinley ore	45,098	24.10	3.54	85.14
Savage ore	21,656	13.37	4.85	64.13

The cost of milling McKinley ore is given as $1.442 per ton milled, and for Savage ore, $0.714.

Beaver Consolidated Mines, Ltd., experienced the same difficulties in 1914 that befell the other companies operating in the Cobalt district. The outbreak of the war caused a cessation of operations, and the mill was closed for two weeks in August. The shortage of power and the low price of silver have also had an adverse effect. The mill treated 26,724 tons of ore, recovering 415,708 oz. of silver in concentrates. Earnings amounted to $158,465. The cost of silver production was $21.54 per ounce. One dividend of $60,000 was paid.

The **Calumet & Arizona Mining Co.,** in common with other copper companies, curtailed production 50 per cent last August. The output for the year 1914 was as follows:

	Pounds copper	Ounces gold	Ounces silver
Domestic ores	49,992,909	19,745	573,606
Purchased ores	2,675,020	4,377	348,537
Totals	52,667,929	24,122	922,143

The net cost of refined copper, crediting value of precious metals, was 9.19 cents per pound. Operating cost at the smelter was reduced 35 cents per ton as compared with the cost in 1913. The blast furnaces treated 403,269 dry tons of ore and 31,299 tons of slag and by-products. The reverberatories handled 238,095 tons of charge. The roasters treated 209,138 wet tons, the average sulphur content of the ore being 27.5 per cent, and of the calcines 9 per cent. The converters produced 32,059 tons of blister copper, and treated 24,823 tons of silicious material. The New Cornelia Copper Company was acquired during the year, and a large amount of experimental work was done on a treatment process. A hydrometallurgical scheme was tested in a 1-ton plant for six months, and later in a 40-ton plant. In the 1-ton plant an extraction of 80.07 per cent was obtained. Copper was precipitated electrolytically at the rate of 0.982 lb. per kilowatt-hour. All the acid necessary was regenerated except a deficiency of 1.4 lb., 100 per cent acid per pound of copper. The report states that the process has been worked out and that future changes will be in detail only. It is understood, however, that flotation has since been adopted.

The Iron and Steel Market

Throughout the iron and steel markets there was decided improvement in July, despite the fact that usually July ushers in a "summer dullness" for the trade. In the steel trade proper the closing days of June witnessed a very material increase in the volume of shipping orders booked, due in considerable part to the fact that in certain commodities there were relatively low-priced contracts that expired June 30, and if specifications were not furnished the tonnages would be canceled. Instead of the activity decreasing in July, however, it increased. The increased demand has been well distributed. The freight car builders, who had booked large orders in May and June, totaling about 50,000 cars for the two months, began to specify freely for the steel required. The agricultural implement trade began to specify against its new manufacturing season. The automobile trade began active preparations for its new season. Export demand increased, for both war and peace materials.

Perhaps the most important influence of all, by a long range view, was the fact that in certain finished steel products the mills began to fall somewhat behind in deliveries. For many months buyers of all products had been in the habit of depending upon very prompt mill shipments, even in the case of orders calling for a wide variety of sizes and descriptions of material. In normally active times, buyers, both jobbers and manufacturing consumers, must carry stocks, for the mills make up their rolling schedules weeks in advance, making as long runs as possible on a size, and thus avoiding frequent roll changes. When orders are scarce they are naturally very accommodating. When the delivery period lengthens from two or three days, or a week, to four or six weeks, as has lately been the case with many commodities, the buyer at once begins to order more material, so as to accumulate a stock. The procedure is well known in the steel trade, and it is recognized that if at any time the mills fall somewhat behind in deliveries demand will take care of itself for quite a period. This extra demand is now being experienced.

Approximately 100 per cent of the open-hearth steel making capacity was engaged during July, and between 70 and 75 per cent of the Bessemer capacity. Open-hearth steel promptly became "scarce," open-hearth billets and sheet bars commanding a premium over Bessemer, as has always been the case in recent years in periods of activity. Steel production at the close of July was at a rate between 85 and 90 per cent of capacity, against about 70 per cent in April and not over about 35 per cent last December.

Our review a month ago noted that in striking contrast with conditions obtaining in the steel market proper the related markets in coke, scrap and pig iron were dull and relatively soft. This anomaly has now disappeared, more activity being shown in these lines, with an advancing tendency in prices. Connellsville furnace coke, which had practically gone begging at $1.75 on contracts for the second half of the year, stiffened to $1.75 for the third quarter and to $2 for the half year, while spot coke, easy in June at $1.50, advanced to about $1.70. Scrap has been more active in all markets. Just after the middle of July heavy melting steel delivered at Pittsburgh mills advanced from $11.75 to $12.75.

Pig Iron

The total pig iron turnover in July was not large, as pig iron sales go, but the volume of business on the whole was considerably larger than in June or May, all markets showing a stiffening tendency, while some ad-

vanced. A development of the month was the withdrawal of the low prices the lake front furnaces had been making in territory normally tributary to other pig iron making districts. Cleveland pig iron had been sold even in West Virginia, and there had been free offerings in Pittsburgh territory in competition with nearby and valley furnaces. The most spectacular transaction was that by which the Cleveland Furnace Company sold about 40,000 tons of basic pig iron to the Youngstown Sheet & Tube Company at not over $13, delivered, this being the first time in history that lake front pig iron was sold to the Mahoning Valley. Not so very many years ago valley pig iron was shipped to Cleveland. Conditions changed after this sale and the valley furnaces resumed sway in the territory usually regarded as their own, and their prices advanced slightly. The Republic Iron & Steel Company bought 16,000 tons of Bessemer pig iron at $14, valley furnace. We quote No. 2 foundry, delivered Philadelphia, $14.25 to $14.50; f.o.b. furnace, Buffalo, $12.50 to $13; delivered Cleveland, $13.50; f.o.b. furnace, Chicago, $13 to $13.50; f.o.b. Birmingham, $9.75 to $10; at valley furnaces, 95c. higher, delivered Pittsburgh; Bessemer, $14 to $14.25; basic, $13; No. 2 foundry, $12.75 to $13; malleable, $12.75 to $13; gray forge, $12.50 to $12.75.

Steel

Market prices on billets and sheet bars advanced sharply during July, not so much by reason of heavy demand in the market as because of heavier specifying by consumers on regular contracts, greatly reducing the tonnage the producers were able to offer in the open market. Subsidiaries of the United States Steel Corporation bought a total of nearly 150,000 tons of billets and sheet bars from mills in eastern and western Pennsylvania, Ohio, and even from one mill in Kentucky, cleaning up all the relatively cheap steel. The market scarcity is only of open-hearth, but Bessemer steel producers have not hesitated to mark up their quotations also, assuming that the market would pay within 50 cents or $1 as much for Bessemer as for open-hearth steel. The market is excited, and it is possible more would have to be paid than quotations here named: Bessemer billets, $21; Bessemer sheet bars, $21.50; open-hearth billets, $22; open-hearth sheet bars, $22.50, f.o.b. maker's mill, Youngstown. There is practically no steel offered by Pittsburgh mills, and the market, delivered Pittsburgh, is quotable $1 per ton over the Youngstown market. Rods are $26, Pittsburgh, and in poor supply.

Finished Steel

The large steel mills had been quoting 1.20c. on bars, plates and shapes for prompt shipment, and 1.25c. on third quarter contracts. At the close of June they withdrew the 1.20c. quotation, according to program, but there remained small mills ready to sell plates at 1.15c. or 1.20c., shapes and bars being fairly well established at the quotation of the large mills. About the middle of July the majority of the large mills withdrew the 1.25c. quotation, naming 1.30c. for any delivery, and this price became established, at least as to bars, while the smaller mills firmed up to 1.25c. on plates. Steel boiler tubes were advanced July 16 by one point or about $2 a ton. While the leading wire interest on June 30 reaffirmed its $1.60 price on nails, sales continued to be made at $1.55. At the same time it advanced painted and galvanized barb wire $2 a ton above the former official figure, and on account of the heavy demand for export this advance held quite well.

Current quotations are as follows for ordinary deliveries, f.o.b. Pittsburgh, unless otherwise noted:

Rails, standard sections, 1.25c. for Bessemer, 1.31c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.25c. to 1.30c.
Shapes, 1.25c. to 1.30c.
Steel bars and bands, 1.30c., base; hoops, 1.30c., base.
Iron bars, 1.20c. to 1.25c., Pittsburgh; 1.30c., Philadelphia; 1.20c., Chicago.
Sheets, blue annealed, 10-gage, 1.35c.; black, 28-gage, 1.75c. to 1.80c.; galvanized, 28-gage, 4.50c.; painted corrugated, 28-gage, 1.90c. to 1.95c.; galvanized corrugated, 28-gage, 4.55c.
Tin plate, $3.10 to $3.20 for 100-lb. coke.
Steel pipe, ¾ to 3-in., black, 79 per cent off list; galvanized, 57½ per cent off list.
Steel boiler tubes (less than carloads), 3½ to 4½-in., 72 per cent off list.
Structural rivets, 1.50c.; boiler rivets, 1.60c.
Railroad spikes, 1.40c. to 1.45c.

The Non-Ferrous Metal Market

No changes of marked importance have occurred in the non-ferrous metal market during the past month. Fluctuations in price have been small. Spelter and lead have declined from the previous high prices; tin has receded a little but copper remains firm.

Copper.—This market has been active and producers have been able to maintain their prices. Small daily fluctuations in price have not been permanent. Demand for brass making continues good, and this business is said to be larger than ever before. Electrolytic copper at New York is quoted at 19.45@19.65 cents.

Tin.—The metal has been plentiful and the price has receded slightly during the month. Buyers seem well stocked and demand has slackened. July tin at New York is quoted at about 38 cents.

Lead.—The high price of 7 cents in June was not long maintained, and the principal producer gradually reduced the price until it reached 5.75 early in July. This price has since been practically maintained, although smaller dealers have offered concessions. The metal is quoted at 5.60@5.75 cents, New York, and 5.50@5.60 cents, St. Louis.

Spelter.—The demand for this metal is stimulating construction of new reduction works and the rejuvenation of some old ones. Good business is reported both domestic and foreign. London quotations continue nominal and a wide variation still exists in domestic prices. At St. Louis the latest quotations are 19.75@21.75 cents.

Other Metals.—The market for aluminium has improved and prices have risen, the New York quotation being 32@33 cents. Antimony continues scarce with high prices, special brands being nominal. Quotations range from 37½ to 52½ cents for different grades. Quicksilver is strong with a good demand. The price for large lots is $94 per flask of 75 lb., New York, and $90@$95 in San Francisco. Smaller quantities bring up to $100 per flask.

Production of Radium by the Bureau of Mines

In a statement issued by Secretary of the Interior Franklin K. Lane in Washington on July 27, it is announced that the production of radium from Colorado carnotite ores by the Bureau of Mines, in connection with the National Radium Institute, has passed the experimental stage in its new process and is now on a successful manufacturing basis. He also declared that the statements made to Congress concerning the ability of the Bureau of Mines to produce radium at a greatly decreased cost over other processes had actually been accomplished and that the costs were even less than predicted.

"The cost of one gram of radium metal produced in the form of bromide during March, April and May of the present year was $36,050, I am informed by Dr. Charles L. Parsons, in charge of the radium investigations of the bureau. This includes the cost of ore, insurance, repairs, amortization allowance for plant and equipment, cost of Bureau of Mines co-operation, and all expenses incident to the production of high grade radium bromide. When you consider that radium has been selling for $120,000 and $160,000 a gram, you will see just what the Bureau of Mines has accomplished along these lines."

"The cost of producing radium in the small experimental plant during the first few months of the Bureau's activities was somewhat higher but not enough to seriously affect the final average.

"The public, however, should not infer that this low cost of production necessarily means an immediate drop in the selling price of radium. The National Radium Institute was fortunate in securing through the Crucible Steel Company the right to mine ten claims of carnotite ores belonging to them and this was practically the only ore available at the time. Since then new deposits have been opened but these are closely held and according to the best judgment of the experts employed by the Bureau of Mines, the Colorado and Utah fields, which are much richer in radium-bearing ores than any others known, will supply ore for a few years only at the rate of production that obtained when the European war closed down the mines. The demand for radium will also increase rapidly, for the two or three surgeons who have a sufficient amount of this element to entitle them to speak from experience are obtaining results in the cure of cancer that are increasingly encouraging as their knowledge of its application improves. A few more reports like that presented to the American Medical Association at its recent San Francisco meeting and the medical profession as a whole will be convinced of its efficacy. Under all the circumstances that have come to my knowledge it does seem to me that it behooves the Government to make some arrangement whereby these deposits, so unique in their extent and their richness, may be conserved in the truest sense for our people, by extracting the radium from the ores where it now lies useless and putting it to work for the eradication of cancer in the hospitals of the Army and Navy and the Public Health Service.

"The ten carnotite claims being operated at Long Park, Colorado, by the National Radium Institute have already produced over 796 tons of ore averaging above 2 per cent uranium oxide. The cost of ore delivered at the radium plant in Denver has averaged $81.30 per ton. This included 15 per cent royalty, salary of Bureau of Mines employees, amortization of camp and equipment and all expenses incident to the mining, transportation, grinding and sampling of the ore.

"A concentrating plant for low-grade ores has been erected at the mines and is successfully recovering material formerly wasted. Grinding and sampling machinery has been installed at Denver and a radium extraction plant erected in the same city. The radium plant has now a capacity of three tons of ore per day, having been more than doubled in size since last February. Before that time the plant had been run more or less on an experimental scale although regularly producing radium since June, 1914. To July 1, slightly over 3 grams of radium metal had been obtained in the form of radium barium sulphate containing over 1 milligram of radium to the kilogram of sulphates. The conversion of the sulphates into chlorides and the purification of the radium therefrom is easily accomplished, and with very small loss of material. Unfortunately, however, special acid-proof enamelware, obtainable only in France, has not been delivered of sufficient capacity to handle the crystalization of the full plant production, so that a little less than half the output, or to be exact, 1304 milligrams of radium element have been delivered to the two hospitals connected with the National Radium Institute. The radium remaining can be crystalized at any time from neutral solution in apparatus already installed, but the greater rapidity and efficiency of production of this very valuable material by the methods used have decided the Bureau of Mines to await the completion of apparatus now being built before pushing the chloride crystallization to full capacity.

"The average radium extraction of all ore mined by the National Radium Institute has been over 85 per cent of the amount present in the ore as determined by actual measurement. The amount present in the ore has been found in fact to be essentially the same as the theoretical amount required by the uranium-radium ratio. The extraction figures for the last five carloads of carnotite treated has shown a recovery of over 90 per cent in each case.

"A bulletin giving details of mining, concentration and methods of extraction is being prepared by the Bureau of Mines and will be issued early in the fall."

Columbia University Establishes a Separate Department of Chemical Engineering

Courses leading to the degree of Chemical Engineer have been offered in the Department of Chemistry of Columbia University for the past ten years but, in recognition of the rapidly increasing importance of those industries based upon the applications of chemistry, and the consequent demand for men specially trained in the fundamental engineering practices as applied to the problems of industrial chemistry, the trustees of Columbia University have established a separate department of chemical engineering which will be placed upon the same plane of importance in the Columbia Graduate Engineering School as mining, civil, electrical and mechanical engineering.

The demand for graduates to fill important positions in the rapidly developing industries of the United States has brought an ever-increasing number of students to study chemical engineering at Columbia, the registration in this subject having reached a total of eighty-one during the past year.

The new chemical engineering laboratories which were recently installed, where the students are taught to use engineering methods and engineering appliances in the study and development of chemical industry, will be provided with still further equipment during the coming summer. In these laboratories research may be conducted on such a scale as to establish dependable engineering data to serve as a basis for intelligent and accurate process design. They are equipped with apparatus to illustrate the fundamental operations of chemical and electrochemical processes, and the student learns by actual contact to apply the fundamental scientific principles to industrial problems. It was here that Dr. Rittman carried on, as a graduate student, his work in the direction of obtaining gasoline, benzol and toluol from residual oils.

The fields in the chemical industry which have been most seriously affected by the European war and in which, in many cases, the supply of European products has been entirely cut off, might be enumerated as follows:

Coal-tar dyes for use in the textile industry; synthetic drugs from which many of our most improved pharmaceutical products are made; synthetic tanning materials for use in tanning our high-grade leathers;

barium compounds; magnesium compounds and a large line of similar high-grade chemicals; chemical and decorated glassware; ferromanganese used extensively in the metallurgical industries; potash and air nitrate for use in fertilizers.

The sudden demand for many of these products has greatly stimulated the activity among chemical manufacturers. In many cases it is necessary first to develop the raw material supplies, as for example for the manufacture of coal-tar dyes, where we are required to obtain a large quantity of benzol, phenol, toluol, etc. The demand for these materials is being met rapidly by the installation of large plants for the recovery of these heretofore wasted products from coke oven gases. Such concerns as the United States Steel Corporation, Lackawanna Steel Company and other large coke producers both in the United States and Canada are now recovering these products. Similar activity obtains in other fields; for example, on account of large demands for explosives, the production of sulphuric and nitric acids is being enormously increased. Entirely aside from these abnormal developments, forced upon the chemical industry by the war, it should be noted that chemical processes are being established in other fields.

Co-operation in Chemical Export Trade to South America

In the Federal Trade Commission hearings, held in Boston in June, on Co-operation in Foreign Trade, some interesting remarks were made with request to the possibility of chemical export trade to South America. We quote from *National Foreign Trade* (Vol. I, No. 3):

Mr. Henry Howard, vice-president Merrimac Chemical Company and Chairman, Executive Committee, Manufacturing Chemists' Association, Boston, Mass., said:

"Our association is made up almost entirely of small manufacturers. When the war broke out, it seemed to our committee an especially good time to investigate the opportunities in South American trade in chemicals, as the German supply was being cut off.

"The first thing we ran up against was that, under the law, it was doubtful if we could form a combination to investigate and comprehensively push our export trade in South America. Eminent counsel advised us it was not safe to do it. Hardly more than three members of the association are large enough to send representatives to South America, and I question if any of them are large enough to send representatives to more than one or two countries. In our own case, there are only three articles we manufacture that would find a market in South America. We could not afford to send a representative because the cost would more than eat up any profit we might get, but we could join in an export association made up of other members of our association, or other manufacturers outside, and contribute toward the maintenance of an efficient staff in all the leading countries, because the expense, apportioned among forty or fifty manufacturers, would be insignificant.

"The great advantage of such an association is that we would be in a position to meet European competition, in foreign trade, where going singly we would not. European business is thoroughly organized and intelligently managed. Even if some of us went individually, we would be afraid, as soon as the war was over, that we would be killed out individually. The foreigners would think twice before starting a fight to eliminate the entire association."

Mr. A. H. Weed, secretary and counsel Manufacturing Chemists' Association, Boston, Mass., said:

"The association, upon request from Washington, prepared a tentative form of a bill necessary to permit the kind of co-operation contemplated. The bill is premised upon the idea that the law should give the absolute and unqualified right to American manufacturers to co-operate for export trade. The effect of such co-operation, whether it be by agreement, combination or association, is to be found primarily in the foreign markets where such agreements, combinations or associations are to be carried out. If the laws of the foreign country permit such co-operation and if our foreign competitors are all acting in combination, within these foreign markets, we should have the right to meet that competition on equal terms. In other words, our anti-trust laws should have no extra territorial effect.

"On the other hand, to prevent any abuses which might result from such co-operative movements, any retroactive effect which a combination might have to restrain trade in the United States, the bill has a provision granting power to the Federal Trade Commission, similar to the power which it now possesses, to restrain unfair methods of competition, under Sec. 5 of the existing law. The proposed bill, therefore, defines export trade on the one hand and 'trade within the United States' on the other."

Possibility of Extra Session of Congress and the Tariff

An important report is in circulation in Washington to the effect that President Wilson is likely to make an announcement shortly which will have great interest in connection with the tariff. This is taken into consideration at the National Capital under the influence of ideas that are reaching there from the business and financial centers of the country concerning what the attitude of the United States is to be after the war in Europe has ended.

Economists in Washington are now giving much attention to the steps that it will be necessary for the United States to take after the war has ended. In these the question of a protective tariff largely figures. Reports reaching Washington from all over the United States are to the effect that business men will be glad to see a readjustment of tariffs. It is especially obvious that the very large sums of money which are now being invested and about to be invested in the creation of new chemical industries (which will make the United States economically and industrially far more independent of other countries than it ever has been), will simply be wasted if these new industries are not to be protected by a suitable tariff and accessory measures.

Senators and other tariff makers now in Washington believe that the early fall would furnish a suitable opportunity to discuss these matters and plan ahead. For that reason there is apparently a growing advocacy of the plan to have Congress reassemble around Oct. 1. This idea obtains support from many Senators and Representatives who are obliged to come to Washington in September to place their children in school, as well as from those who are anxious to begin as early as possible upon the fight as to whether or not there shall be a great increase in the military preparedness of the United States, sure to come this winter.

Again, some Senators and Representatives are urging an early session of Congress because of the fact that almost all of the important questions at the coming session will furnish material upon which the 1916 political fight is to be waged and because the national political conventions meet in the summer of 1916, by which time, they hope Congress will have completed all of its labors. Thus, they advocate an early start this fall.

Cyanidation of Low-Grade Sulphide Ores in Colorado—II

BY H. C. PARMELEE

Caribou, Boulder County

In the early history of Colorado mining, Caribou was a well known camp in Boulder County, springing into prominence about 1869 and continuing active with a wonderful production of silver until 1893. In 1888 the famous Caribou mine was closed as a result of litigation, and the camp went into a decline which culminated in 1893 with the fall in the price of silver.[1] Through this combination of circumstances, but particularly on account of the slump in the silver market, Caribou suffered the fate which overcame other silver mining camps in Colorado. It was gradually deserted, the mines filled with water, fire devastated a once populous camp, and Caribou became a place of only historical interest.

The silver production credited to Boulder County, from 1869 to 1893 came mainly from the Caribou, Poorman and other mines, all located in a restricted area at Caribou. In round numbers, the annual silver output of the county began with 3500 oz. in 1869, rose to 348,-000 oz. in 1879, dropped to 250,000 oz. in 1893, and finally slumped to 75,000 oz. in 1894. Aside from the known production of some unusually large nuggets of silver, the richness of the ore is attested by the early records which show profitable operation under a mining cost of $17 per ton, and transportation and treatment charges of $45, or a total of $62 per ton. Raymond[2] states that in 1869, 26 tons of Caribou ore shipped to the Hill smelter at Black Hawk had a gross assay value in silver of $3,217, and that in 1870, 425 tons shipped to the same place had a gross silver value of $73,772. For the treatment of low-grade material, say 60-oz. silver ore, which would not stand the cost of shipment, there was erected a lixiviation mill at Nederland, four miles from Caribou.

It can be readily appreciated that at the time the Caribou and Poorman mines were worked, a vast quantity of what was then low-grade ore was left unmined, used as stope filling or thrown on the dump. It will also be apparent that, due to the progress in metallurgy in 30 years, such an abandoned property might now become a source of profit if properly sampled and tested, and equipped with a suitable treatment plant. This possibility having been brought to the attention of Mr. Henry P. Lowe, he undertook first the sampling of the dumps, and later, after getting encouraging results from this work, the unwatering and sampling of the mines. The Cariman Mining & Milling Co. was organized and a modern concentrating and cyaniding mill was built.

The dumps were carefully and systematically sampled through trenches and shafts, large lots of material being crushed, automatically sampled and assayed. Later these same lots were used as the basis of concentration and cyaniding tests, so that a safe foundation was laid for any subsequent work that might be justified by the results obtained. The original tests were checked by an independent engineer who practically confirmed the first results. In many of its aspects the problem here presented recalls that which confronted the engineers for Stratton's Independence in sampling and testing that dump. The latter project was greater in magnitude and the valuable metal was gold instead of silver, but similar principles were involved, and, strangely enough,

similar treatment was ultimately adopted at both mines, viz., concentration and cyanidation.

The sampling of the Caribou dumps showed an average silver content of from 7 to 8 oz. per ton. The gold value varied from 40 to 70 cents per ton. The quantity of ore in the dumps was estimated at 135,000 tons. The tests indicated a total extraction of 85 per cent, of which 35 per cent was by concentration and 50 per cent by cyanidation. Flotation was not considered as a possible means of treatment on account of the prohibitive royalty demanded. The unwatering and sampling of the mines revealed the possibility of securing a large tonnage of ore from filled stopes and low-grade
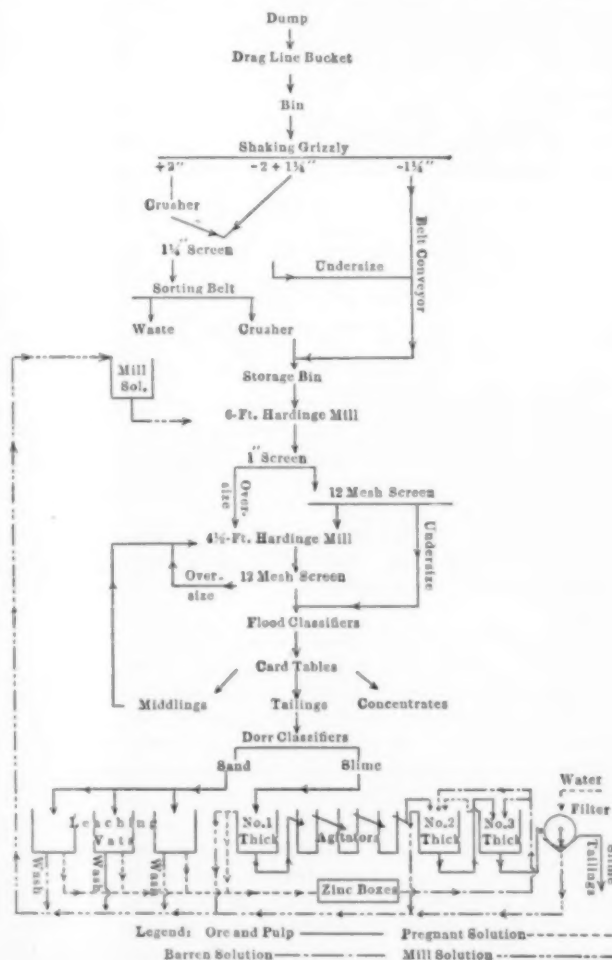
FIG. 1—FLOW SHEET CARIMAN MILL

veins that would average 15 oz. silver per ton. The final result of the sampling and testing which was carried on over a period of nearly two years, was the construction of a modern concentrating and cyaniding mill of 125 tons daily capacity, which has been in operation for over six months.

Cyanidation of Silver Ores at the Cariman Mill

The silver in Caribou ore occurs both native and as sulphide. Galena is present in small quantity, and occasionally chalcopyrite occurs. The gangue is granitic and exceedingly hard.

The ore is conveyed from the dump to bins at the coarse-crushing and sorting department by means of a drag-line bucket fitted with manganese-steel teeth. This method of reclaiming the dump has proved effective and economical, the cost averaging 4 cents per ton. From the bins the ore is fed over a shaking grizzly, with bars spaced two inches apart and below them a steel

[1] The price of an ounce of silver in 1869 was $1.32; in 1879, $1.12; 1890, $1.05; 1893, $0.78.

[2] Raymond, R. W., "Mineral Resources West of the Rocky Mountains."

plate punched with 1¼ in. round holes. The grizzly yields three products, as shown in the flow-sheet, Fig. 1. The size minus 1¼ in. is conveyed directly to the bins above the Hardinge mills. The largest size is crushed, combined with the medium size and screened through a trommel with 1¼-in. holes. The oversize from this screening operation is hand-sorted, sufficient barren granite being removed to raise the value of the mill feed from 25 per cent to 30 per cent above the gross value of the dump. Up to this point the ore is crushed dry, but beginning with the regrinding, mill solution is added. Lime also is added to the feed of the first Hardinge mill.

Hardinge conical mills have been selected for the medium and fine grinding. The first mill is 6 ft. in diameter, lined with manganese-steel ribbed ates and charged with 5-in. manganese-steel balls. ie second and smaller mill is 4½ ft. in diameter, fitted with similar lining and charged with 3, 2 and 1-in balls. On account of the hardness of the ore, pebbles have not been found efficient grinders for the smaller mill.

Experience with Britannia Lining

The so-called Britannia lining, made of short pieces of rail set on end and embedded in cement, was originally furnished with one of the Hardinge mills. The lining failed after a very short run and was reset according to specifications with a strong cement mixture. After allowing ample time for the cement to set and dry the mill was again put in commission, but the lining lasted for only a few hours. The impact of the heavy balls loosened the rails and in a short time the lining was entirely broken up. Considering the time required to put this type of lining in place and allow it to set and dry, together with the very short service obtained, the experience with it was wholly unsatisfactory. Manganese-steel linings have since been used with satisfactory results.

The maximum size of feed to the first Hardinge mill is 1¼ in. The product is screened as shown in the flow-sheet, and the unground portion treated in the second mill. Twelve-mesh is the maximum size of the final product, and at this size concentration begins. There are no new features of importance in the concentrator. The pulp is hydraulically classified in Flood classifiers and distributed to Card tables. The concentrate is a finished product and is shipped to the smelter. A small amount of middling is returned to the second Hardinge mill, and the balance of the pulp, sand and slime tailing, is sent to the cyanide department.

About 35 per cent of the silver in the ore is recovered in a concentrate containing 100 oz. silver and 0.50 oz. gold per ton, with 5 per cent of lead.

Separate Treatment of Sand and Slime

The tailings from the concentrating tables flow to a duplex Dorr classifier where a separation is made between sand and slime, the dividing point being 100-mesh. The two products are about equal as to tonnage. The sand is elevated to a distributor and charged into leaching vats. Percolation begins as soon as a substantial layer of sand has formed on the filter-bottom, and continues while the vat is filling. The average rate of filling is 2.6 tons per hour, so that a 135-ton vat is under percolation for about 55 hours. During this period the solution is strengthened to 2.5 lb. KCN per ton. When the vat is full, mill solution at a strength of 1.7 lb. is turned on for about 100 hours. This is followed by a water wash for from 20 to 30 hours, according to the time available before the vat is required for a new charge. The pregnant solution obtained while filling the vat and during the wash with mill solu-

tion all flows to the clarifier and thence to precipitation. The water wash flows to the mill-solution sump. Sluicing requires from 8 to 10 hours on a 135-ton vat. An automatic sand sample is taken while the vat is filling. As the distributor revolves, the stream issuing from the longest arm passes over a slotted pipe connected with a sample box, so that with each revolution of the distributor a small quantity of the pulp is cut out.

A change made in the discharge gates on the sand vats has removed some difficulties formerly encountered. Originally the gates were of the usual type, hinged at one side and locked in place by wedges. At times the wedges would break. Again, it was necessary to have a movable launder in order to open and close the doors. The movable launder was responsible for sand spills, and at times a heavy tonnage would overflow before it was noticed. In order to obviate these troubles the doors have been tapped and threaded to receive a 6-in. plug or a 6-in. diameter pipe of suitable length to reach a permanent launder. To discharge a vat the plug is removed and replaced by the pipe which is screwed in loosely by hand. In replacing the plug it is necessary only to screw it in as tightly as may be required to avoid leakage, and if this cannot be done by hand a few turns with a wrench will suffice.

Continuous Counter-Current Decantation

The slime treatment is clearly shown in the flow-sheet. Decantation and agitation are continuous through a series of one Door thickener followed by three Dorr agitators and two Dorr thickeners. A Portland revolving filter is placed at the end of the system to recover cyanide. The overflow of No. 1 Dorr thickener is diverted either to the mill-solution sump or to the clarifier for precipitation, according to requirements. Enough of this overflow is added to the pregnant solution from the sand vats to keep the clarifying leaves submerged, and to furnish a constant supply for the zinc boxes.

The transfer of pulp from the thickeners is accomplished by means of Colorado Iron Works diaphragm pumps, which were illustrated and described in our last issue. The length of stroke of these pumps is regulated by adjusting an eccentric. At the Cariman mill the pumps are set for maximum stroke, and the quantity of pulp actually lifted is then controlled by means of an air-cock which admits air to the pump suction. No difficulty is found in thickening the slime pulp to 50 per cent moisture, and this is the standard usually maintained. Tests are made three times per shift by taking a measured quantity of slime from the discharge of the diaphragm pumps and suspending it on an ordinary spring balance with dial and indicator. A scale indicating per cent moisture, calculated from slime tables, is placed on the dial so that the moisture content is read directly.

The strength of cyanide solution is raised to 3 lb. per ton at No. 1 agitator. The agitators are run in series and the transfer of pulp is effected by gravity through adjustable transfer pipes.[1] The period of agitation is from 36 to 40 hours. On account of the sandy nature of the slime, it being ground to only minus 100-mesh, difficulty was experienced at first in keeping the transfer pipes open and pulp flowing freely. At times sand accumulated in the pipes and restricted the flow until the tanks overflowed. This has been entirely overcome by introducing compressed air through a ⅜-in. line into the transfer pipes, producing, in effect, a small air-lift. The connection between the air line and the transfer pipe is flexible so that the position of the

[1]See this Journal, Jan., 1915, page 13

latter can still be adjusted as required. The quantity of air used is negligible.

The principle of impoverishing slime by decantation before filtering is now generally recognized as good practice. At the Cariman mill the function of the Portland filter is the recovery of chemicals in solution and the dewatering of the slime tailing. Dissolved silver in the slime is practically removed in the decantation process and the value of chemicals remaining in the slime pulp is greater than that of recoverable silver. A typical group of assays of filter head and tailing samples is as follows: Filter head, unwashed, 0.64 oz. silver per ton; filter head, washed, 0.34; filter tailing, unwashed, 0.42. This indicates a loss of dissolved silver of but 0.08 oz. per ton. The mechanical loss of cyanide at the filter is 0.18 lb. per ton of solution discharged in a pulp of 35 per cent moisture. Water is added as a wash in sufficient amount to balance the moisture lost in the discharged slime.

The pulp in the filter tank is kept in suspension by means of compressed air introduced from four jets spaced equidistant along the bottom edge of the tank. Once in 24 hours these jets are opened, one at a time, until all the settled slime is in suspension. The air-lifts usually provided to keep the pulp in circulation have not been sufficient to prevent settlement in this particular case. They had the effect of merely pulling holes through the settled slime without disintegrating it.

The daily control of the work in the slime department requires the assay of the following pulps and solutions: Washed slime head, overflow from all thickeners, filtered solution from pulp in No. 3 agitator, washed pulp from No. 3 agitator, unwashed and washed pulp from underflow of No. 3 thickener, which constitutes the filter head; filter effluent, and unwashed filter tailing.

Precipitation and Refining

The pregnant solution from the sand vats and a varying portion of the overflow of No. 1 thickener is clarified through filter leaves under vacuum. The clarifier solution is pumped to a constant-head tank from which the zinc boxes are fed. Solution is precipitated at the rate of 1.8 tons per ton of ore. The head solution assays from 1.5 to 1.75 oz. silver per ton, and the tailing solution from 0.02 to 0.05 oz. No lead acetate is used or other special treatment given. A clean-up is made once in ten days, and a precipitate obtained assaying from 15,000 to 18,000 oz. silver and 50 oz. gold per ton.

Up to the present time no means for acid treatment have been provided, and the precipitate is given merely a light roast in a Case muffle roasting furnace. It is then fluxed and melted in a Case tilting crucible furnace. Both furnaces have gravity oil feed and air blowers, and give excellent satisfaction. A further description of the tilting furnace and burner appears elsewhere in this issue.

On account of the current high prices for chemicals, several fluxes have been tested to secure one that would prove efficient and economical. The one finally adopted contains the following materials in parts by weight: Soda, 5; borax, 3.5; silica, 1.5; manganese dioxide, 1. This has been used at the rate of 75 lb. per 100 lb. of precipitate. Manganese dioxide was selected in place of nitre, as the respective prices of the two chemicals at Denver is now about 10 cents and 20 cents per pound.

Power and Labor

Electric power is one of the modern conveniences that make possible the operation of such isolated mills as the Cariman. Situated at an altitude of over 10,000 feet and two miles from the railroad, the cost of coal

delivered at the mill would be prohibitive in milling low-grade ore. Under present conditions electric power is available for all operations, and the only need for fuel is to heat the mill in winter. All motors are of ample size for the work required, as follows: Drag-line bucket, 20 hp.; belt conveyor, 5; coarse crushers, 35; Hardinge mills, 75; concentrator, 10; wet elevator, compressor and all cyanide machinery, 50.

The mill is designed to require the minimum amount of labor. All coarse crushing is done on one shift, requiring one man on reclaiming the dump and one at the crushers. In the mill there is one man per shift at the Hardinge mills, concentrator and in the cyanide department. Wages range from $3 to $4 per day.

Miscellaneous Data

The mill solution contains 1.7 lb. KCN per ton, with protective alkalinity of 2 lb. CaO. The latter may vary between 1.8 and 2.2, but outside of these limits the settlement of slime in the thickeners is seriously affected. At the sand vats the solution is strengthened to 2.5 lb. KCN, and at No. 1 agitator to 3 lb. The

FIG. 2—CARIMAN MILL, CARIBOU, COLO.

consumption of cyanide is 1 lb. per ton of ore, and occurs almost entirely at the agitators. The mechanical loss of cyanide in leaching is from 4 to 6 lb. per vat of 135 tons. At the filter the mechanical loss is 0.18 lb. KCN per ton of solution. The lime consumption is five lb. per ton of ore. Mine water is used throughout the mill, and solutions are kept at normal mill temperature, about 55 deg. Fahr. in winter and 65 deg. Fahr. in summer.

The figures for the month of June show an average mill feed of only 4.8 oz. silver per ton. This was unusually low, due to the necessity of removing a lean part of the dump in preparation for some construction work. The concentrators recover 35 per cent. The average assay of the sand product was 2.1 oz. silver, of which 71.4 per cent was recovered. The average assay of the slime was 1.2 oz. silver, and the extraction 78.3 per cent. This amounts to a gross extraction of 85.8 per cent, or 4.12 oz. silver per ton. The total milling cost is estimated at $1.72 per ton.

The mine is now being equipped for production next winter, it being the intention to treat the dump ore only in summer. When all arrangements now planned are in working order it should be possible to maintain an average mill feed of 7 to 8-oz. ore from the dump and 15-oz. ore from the mine. The entire project affords an excellent example of revival in an old mining district, due wholly to improved methods of metallurgy and facilities for economic operation.

To Mr. Henry P. Lowe, and members of his staff, we are indebted for the data here given and for many courtesies extended in the preparation of these notes.

The Effect of High Ignition-Voltages on the Accuracy of Bomb Calorimeter Determinations

BY EDWARD J. DITTUS

In the determination of calorific values with the bomb calorimeter it is necessary to ignite the weighed portion of the substance in an atmosphere of oxygen, under pressure, by melting a small piece of iron wire (approximately 0.01 gram) with an electric current. A small calorific increment results, due to the passage of the current. It is contended that high voltages enhance this increment.

In order to determine the value of this source of error, several experiments were made with the apparatus shown in Fig. 1 and under conditions indicated.
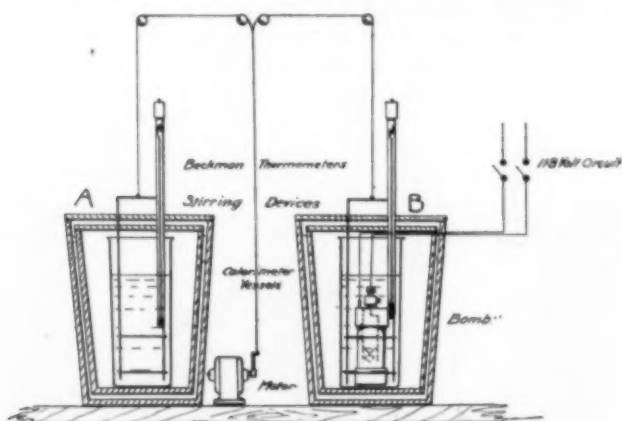
FIG. 1—APPARATUS FOR CALORIMETRY

Calorimeter A was used only as a blank to determine the variation of the temperature of the water contained, due to changes in room temperature. Calorimeter B was prepared as for a combustion, but no combustible material was introduced. No. 34 Brown & Sharpe gage iron wire was used to connect the two terminals, and the bomb contained oxygen under a pressure of 20 atmospheres. The terminals were connected to a 118-volt direct-current circuit. The two stirring devices were operated by the same motor, and the two Beckman differential thermometers were identical.

Before beginning an experiment the two thermometers were adjusted, as nearly as possible, to read the same. The difference in the reading was taken as a constant because the temperature range was in all cases very small, and the error from this source, therefore, small.

The same quantity of water (1500 grams) was used in each calorimeter, and in all experiments it was allowed to stand at least two hours in order to obtain temperature equilibrium. It was impossible to obtain the same temperature of the water in both calorimeters. Temperature readings were, therefore, made in each calorimeter until the difference was constant, and this difference assumed constant for all subsequent readings.

In making an experiment, a temperature reading was taken on each calorimeter, and immediately thereafter the 118-volt circuit was momentarily closed. Temperature readings were then taken at fifteen to thirty second intervals for ten minutes.

Three experiments were thus made and the data recorded as shown in tabular and graphic form. In the tables, the column "Corrected Bomb Temperature" was computed by adding to the "Bomb Temperature" the sum of the difference in the initial readings of the two differential thermometers and the constant difference in the temperature of the water in the two calorimeters.

EXPERIMENT I

Weight of water in each calorimeter.............................1500 g.

Initial difference in temperature of water.......................	0.865° C.
Initial difference of Beckman thermometers....................	0.765° C.
Total difference..	1.630° C.

READINGS

Time, Seconds	Temperature Blank	Temperature Bomb	Corrected Bomb Temperature
0	5.270	3.640	5.270
30	5.280	3.650	5.280
60	5.280	3.655	5.285
90	5.280	3.645	5.275
120	5.280	3.645	5.275
150	5.290	3.630	5.260
180	5.290	3.625	5.255
210	5.290	3.620	5.250
240	5.290	3.620	5.250
270	5.295	3.610	5.240
300	5.295	3.610	5.240
360	5.295	3.590	5.220
420	5.295	3.580	5.210
580	5.295	3.565	5.195
640	5.295	3.550	5.180
710	5.295	3.530	5.160
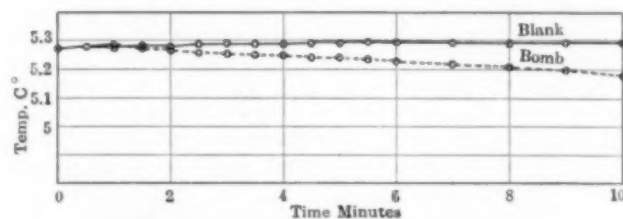
EXPERIMENT 1 WITH BOMB CALORIMETER

EXPERIMENT II

Weight of water in each calorimeter.............................1500 g.

Initial difference in temperature of water.......................	0.320° C.
Initial difference of Beckman thermometers....................	0.135° C.
Total difference..	0.455° C.

READINGS

Time, Seconds	Temperature Blank	Temperature Bomb	Corrected Bomb Temperature
0	1.215	0.760	1.215
15	1.220	0.770	1.225
30	1.230	0.780	1.235
45	1.240	0.780	1.235
60	1.245	0.790	1.245
90	1.250	0.790	1.245
120	1.260	0.795	1.250
150	1.270	0.800	1.255
180	1.280	0.810	1.265
210	1.290	0.815	1.270
240	1.300	0.825	1.280
270	1.315	0.830	1.285
300	1.325	0.835	1.290
330	1.335	0.840	1.295
360	1.350	0.850	1.305
390	1.360	0.860	1.315
420	1.370	0.860	1.315
450	1.380	0.870	1.325
510	1.410	0.880	1.335
570	1.430	0.895	1.350
630	1.455	0.910	1.365
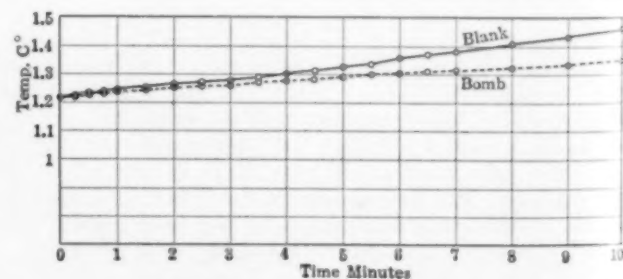
EXPERIMENT 2 WITH BOMB CALORIMETER

Summarizing the data obtained in the three experiments I, II, and III, we get the results given in table IV.

EXPERIMENT III

Weight of water in each calorimeter..........................1500 g.

Initial difference in temperature of water....................... 4.020° C.
Initial difference of Beckman thermometers.................... 0.150° C.

Total difference.. 4.170° C.

READINGS

Time, Seconds	Temperature Blank	Temperature Bomb	Corrected Bomb Temperature
0	5.710	1.540	5.710
30	5.710	1.540	5.710
60	5.710	1.540	5.710
90	5.720	1.550	5.720
120	5.720	1.550	5.720
150	5.730	1.560	5.730
180	5.730	1.560	5.730
210	5.730	1.560	5.730
240	5.730	1.560	5.730
270	5.740	1.570	5.740
300	5.740	1.570	5.740
330	5.740	1.570	5.740
360	5.750	1.580	5.750
420	5.755	1.585	5.755
480	5.760	1.590	5.760
540	5.765	1.595	5.765
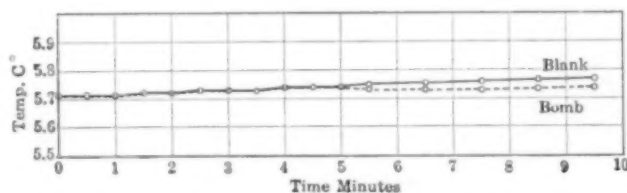
EXPERIMENT 3 WITH BOMB CALORIMETER

TABLE IV

No. of Experiment	Difference in Temperature, Blank and Bomb	Resultant Error in Gram-Calories Using 1500g. Water and 0.5g. Coal	Percentage of Error on 1g. Coal on Assumed Basis of 7000 Gram-Calories
1	0.005	7.500	0.25
2	0.005	7.500	0.25
3	0.000	0.000	0.00
Average....			0.166

The above data lead to the conclusion that unless great accuracy is required the ignition voltage is not an important consideration. That is, in the determination of the calorific value of coal, oil, etc., an error of 0.2 per cent is permissible, and the ignition voltage need not be seriously regarded.

Metallurgical Laboratory,
  Colorado School of Mines.

The **new benzol plant** of the Inland Steel Co. at Indiana Harbor is now practically completed. A similar plant is being installed by the U. S. Steel Corporation at the Gary works.

Silica-Graphite Paint.—A practice that is fast gaining adoption in progressive power plants is the use of paint for the inner surface of steam boiler drums. The paint is said to afford protection against pitting. Silica-graphite paint is used for this purpose and for a number of years the manufacturers of this paint have coated the steam drums of five B. & W. boilers developing 1800 hp. and as a result the drums are in almost perfect condition. Another instance, in a plant equipped with B. & W. boilers developing 8400 hp., the interiors of the drums were scalded, painted both above and below the water line and allowed 48 hours to dry thoroughly. This treatment was repeated every ten months, and not only did it stop pitting but where it had previously taken six men seven days to clean the drums of one boiler, two men now clean them in a day. This latter experience is quoted from a letter of the Chief Engineer of the New York Life Insurance Company, in the April issue of *Graphite*.

The Potash Situation

BY SAMUEL H. DOLBEAR

The pressing necessity of a source of potassium salts independent of the control of the German Kali Works has never been so apparent as now. The absolute embargo placed upon the export of potash in all forms by the German government has created a most serious situation for the potash consumer. Arbitrary treatment of American buyers by the German syndicate in the past has, it is true, created some little feeling, but heretofore the question has been largely that of price, while now the consumer finds himself unable to secure any part of his wants at any figure.

At least one source of potash in commercial quantities is now known to exist in the United States, at Searles Lake, San Bernardino County, California, and it is possible that the intensive search which has been conducted by the United States Geological Survey, the Bureau of Soils, and by private individuals may result in making known other deposits.

Proverbially, large bodies move slowly. The Searles Lake enterprise easily qualifies in such a class, and while the engineers and officials of this project are working intelligently and with as much speed as will secure ultimate results, no immediate production of potash in large quantities is expected. The problem of transportation has been solved by the construction of a branch railroad from Searles, on the Southern Pacific Railroad, to the new town of Trona, on the northwestern edge of Searles Lake. This work was done by the Trona Railway, a corporation financed by the American Trona Company, which is the operating concern. The California Trona Company continues as the owner of the property, which originally comprised about 250 placer locations of 160 acres each—a total area of approximately 40,000 acres.

The serious problem at Searles Lake is essentially a chemical one, involving the separation of potassium chloride from a solution containing also sodium carbonate, sodium chloride, sodium sulphate, sodium borate and other saline substances. The process worked out by John W. Hornsey, and for which an experimental unit designed to produce 5 tons of potash per day was built, has been abandoned as not practical. A new process has been developed by a New York engineer, which it is believed will successfully make this separation, but details of this new process have not been made public.

There is still some litigation with regard to the title to the company's claims. The California Trona Company filed application for patents on certain of its claims, and the granting of the patents has been protested by Victor Barndt. The reasons for the protest are unusual, being based on the following grounds: (1) Attempt to establish a monopoly; (2) failure of locators to make discovery; (3) that the locations were not made in good faith. The first claim hardly seems to deserve serious consideration for the reason that the presence of potash was not known to the locators when the claims were filed. Anent failure to make discovery, that is, of course, a matter to be determined by evidence. The third basis quickly resolves itself into the question of "What is 'good faith'?" The question in this case is really that of determining what is a sufficiently valuable consideration to constitute a valid transfer of title.

Aside from the work at Searles Lake, efforts have been directed along three other lines in the United States with a view toward securing a potash production: (1) From "vinasse" or refuse from a distillery in California; (2) from California kelp, and (3) from siliceous rocks in which potash occurs in an insoluble state.

During the past year the Pacific Chemical Company

commenced the construction of a plant at Agnew, Cal., on a site adjoining the distillery of the Western Grain & Sugar Products Company, and plans to use the refuse "vinasse" of the latter concern. No production has yet been made.

At Point Loma, San Diego County, Cal., the Kelp Products Company has built an experimental plant to extract potash from kelp. The plant is also designed to dry the kelp commercially for use as fertilizer. The kelp is harvested with a mower device which extends 6 ft. below the surface of the water. After being mowed the plants are carried by a conveyor into a barge. When loaded this is towed ashore to the company's wharf, on which has been placed a chopper. By means of a conveyor the plants are delivered from the barge into the chopper. From the chopper discharge the material is carried on another conveyor to a rotary tubular calciner in which a sufficient heat is maintained to thoroughly dry the chopped kelp. The dried product is then ground and sacked for shipment. According to the officials of the company, the dried product contains 15 per cent K_2O, 2 per cent N, and $\frac{1}{2}$ per cent P_2O_5.

When it is desired to extract the soluble potash content from the kelp a different course is pursued. Under the patent which the company holds, a deglutinizing agent is fed into the chopper while the plants are chopped very fine. The juices are then pressed from the kelp and the residual pulp dried. The juices are then artificially evaporated and the salts allowed to crystallize.

A careful study of the chemistry of these kelps has been made under the direction of the College of Agriculture of the University of California. This institution has recently published a bulletin compiled by John S. Burd, entitled "The Economic Value of Pacific Coast Kelps."

The possibility of recovering potash from feldspar and feldspathic rocks has been very fully discussed by Messrs. Allerton S. Cushman and George W. Coggeshall in METALLURGICAL & CHEMICAL ENGINEERING in the issues of November, 1912, and February, 1915.

THE EUROPEAN SITUATION

Importations of potash into the United States were disturbed immediately upon the declaration of war in Europe, and months before Germany had established the absolute embargo, there existed what then seemed a critical shortage in supply. The extent of the interruption may be appreciated when it is known that in the fiscal year ending June 30, 1914, there was imported into the United States 1,066,929 tons of potash salts for fertilizers. Importations for the six months July 1, 1914, to Dec. 31, 1914, amounted to only 182,192 tons, as against 567,595 tons for the same period in 1913, thus leaving a shortage on Jan. 1, 1915, of 384,403 tons.

The turnover of the German Kali Syndicate in 1914 amounted to approximately 156,000,000 marks ($37,-128,000), a decrease compared to 1913, when the amount was 192,000,000 marks ($45,696,000). In view of the rapid increase in production just prior to the war, it seems probable that had war not been declared the turnover for 1914 would have been about 210,000,000 marks ($49,980,000).

While authentic data regarding the present operations of the German Kali Works is not available, it is known that about one-half of its employees have gone to the front as soldiers. It is interesting to note that these men are being paid their usual wages while engaged in military duty.

There are two points of particular interest in the European potash situation at this time: the case of Alsace, and the prospect of securing a supply in Spain.

In Alsace, so far as is now known, the deposits underlie an area of nearly 7 sq. miles. They range in thickness from 6 to 30 ft., and contain an estimated tonnage of 1,472,058,000 tons of potash salts. It is reported that explorations carried on in Baden, across the Rhine from the Alsatian mines, indicate the probable extension of the deposits into that section also. The future possession of Alsace is possibly now in doubt, and should the administration of that country pass out of German hands, potash from its mines might compete with the German product.

The presence of potash in the Provinces of Barcelona and Lerida in Spain has been known for several years, but only during the past year or two has general interest centered here as a possible competitor to the Strassfurth deposits. This possibility seems to have been appreciated by the German interests and much of the new fields had been taken up by them prior to the outbreak of war last year. Anticipating that German control might simply result in the complete shutting down of the mines, the Spanish government have prepared laws which require the constant operation of the deposits by those holding mining privileges. While investigations made so far seem to indicate that only enough potash may be found here to supply the demand in the Spanish markets alone, such investigations are far from complete, and sentiment in Spain does not seem to respond to the doctrine of conserving these resources for local use exclusively.

Aside from those concessions which have passed into the hands of German principals, others have been secured by French capital. All of the lands so far taken up are in a limited region along the Cardona River near the towns of Suria and Cardona. The claims do not go beyond Solsona on the north, and Tarrega, Servera and Manresa on the south. The Geological Survey of Spain is now conducting a careful investigation of this area, and while this research is being made all free lands have been reserved from entry. Under the new law, the government itself may undertake the exploitation of all minerals which can be utilized in the manufacture of fertilizers.

The American Consul General at Barcelona has reported that under the most favorable circumstances no production of potash could be made before the latter part of 1915, and that the development of these fields has been seriously affected by the present war.

OTHER FOREIGN SOURCES OF POTASH

The niter deposits of India, Chili and Africa furnish some potash salts, although the amounts produced are relatively small. About 10,000 tons is annually exported from India, while the Chilian production is about 20,000 tons. In Scotland, Norway and Japan small amounts of potash and iodine are extracted from kelp, and in Russia a small amount of potassium carbonate is made from the ashes of sunflower stalks. In Canada, potash is leached from wood ashes in the big lumber mills.

The development of a potash industry in Utah seems assured in the near future. The Mineral Products Co. has contracted for the construction of a tramway near Marysvale, Utah, for the purpose of transporting alunite to a treatment plant which is to be erected.

Ferromanganese Made at Niagara Falls.—The firm of E. J. Lavino & Company, Phila., Pa., has started the manufacture of 80 per cent ferromanganese at Niagara Falls, N. Y., and it is our understanding that they have made arrangements to supply the American trade with their future requirements. Since the war started, the supply of ferromanganese from Europe has been a source of worriment to the steel industry.

Possible Applications of Oxygen in Metallurgy

Oxygen Blast for the Iron Blast Furnace

Before the Mining and Metallurgical Society of America, Mr. J. E. Johnson, Jr., discussed recently in an interesting manner some possible applications of cheap oxygen, especially in the metallurgy of iron (*Bulletin*, Vol. VIII, No. 2). In view of the fact that oxygen at lower and lower cost has become a commercial commodity in recent years, and that developments tending to reduce the cost of oxygen still further appear to be close to realization in the near future, Mr. Johnson's remarks are particularly timely and suggestive.

"One of the developments of the past five years has attracted less attention than it deserves, because its first steps were obscured by charlatanery and chicanery. I refer to the progress of separating air into its component oxygen and nitrogen on an industrial scale by distillation from liquid air, a process which is in actual operation at Niagara Falls, separating many thousand cubic feet of air per hour.

"Those who remember the ridiculous claims made for liquid air some sixteen years ago, and their subsequent utter collapse, are inclined to deny the commercial possibility of that operation, on theoretical grounds, but this is not correct. The theoretical power, figured on the basis outlined by Ostwald, the great apostle of physical chemistry, amounts to only 1 hp. per 6 cu. ft. of oxygen produced per minute. A modern 500-ton blast furnace needs 45,000 cu. ft. of air or 9000 cu. ft. of oxygen per minute, which would require, on the theoretical basis, 1500 hp. for its production, as against the 2500 hp. now necessary to blow the furnace.

"The best performance of any actual air separating operation to-day requires about seven times the theoretical amount of power, so we are still far from being able to replace existing methods on the power basis. Processes are under development, however, which promise to reduce this power requirement by one-half or two-thirds; in other words, we hope to produce oxygen at any efficiency of 50 per cent, based on theoretical power, and there is no fundamental reason why we should not do so. Even this, you will say, is no improvement over present conditions, and on the power basis alone that would be true. But this question cannot be decided on the power basis alone for two reasons: First, the heat consumption of the blast under present blast-furnace conditions is not limited to power alone. Second, the result in the furnace itself must be considered.

"In regard to the first point, it must be remembered that the blast must not only be compressed but it must be heated, and this operation requires about four times the heat required to supply power for compression; then there is the heating equipment which costs as much as the power plant, all of which would be saved by the use of oxygen. This brings us to the second point, the effect of oxygen in the furnace itself.

"In the furore which arose over the dry blast just ten years ago you may remember that a new theory of the blast furnace was brought out, which supplements the old theory in precisely the same way that the second law of thermodynamics supplements the first, and, curiously enough, is expressed by identically the same mathematical formula. This new theory rests on the fact that quantity of heat alone is not sufficient; the temperature at which it can be applied is just as important.

"We know as a matter of practical observation that a furnace will not operate properly unless the slag be raised to or above its free-running temperature, therefore that some of the heat required for the process must

be supplied at or above that temperature. Since, under given conditions, the quantity of this heat bears a definite ratio to the total quantity, the first, which I call for convenience the 'hearth heat,' is just as important as the second. As a matter of fact, whichever quantity first falls below the requirements sets a limit to economy whether the other be present to excess or not, and in 95 per cent of the cases it is the quantity of hearth heat obtainable per pound of fuel which limits fuel economy.

"If we know the critical temperature it is easy to calculate this latter quantity for any given condition. I recently had occasion to calculate it for dry blast at 1000 deg. Fahr., and for a mixture of equal weights of oxygen and nitrogen (at atmospheric pressure) for different critical temperatures. The results are shown in Fig. 1. The critical temperature in ordinary coke practice is well established as about 2750 deg. Fahr., and you will see that at this temperature the hearth heat, with ordinary hot blast, is about 1600 B.t.u. per pound of coke, while with 50 per cent oxygen it is 2400 B.t.u., so that with 50 per cent oxygen blast an ore which now requires 2100 lb. of coke would require only
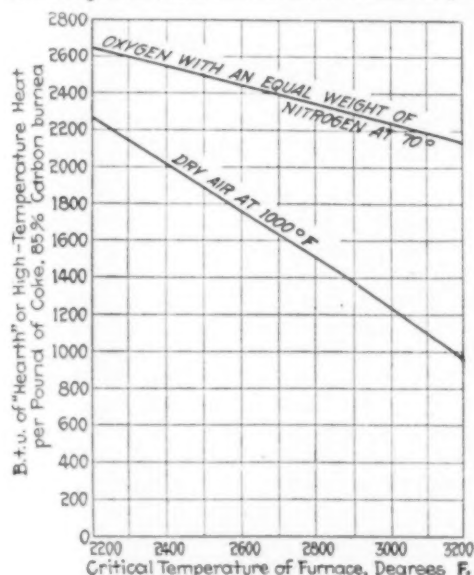
FIG. 1—DIAGRAM SHOWING HEARTH HEAT PER POUND OF COKE

Counting 85 per cent fixed C burnt in hearth, at different critical temperatures with blast of dry air at 1000 deg. Fahr., and with blast containing equal weights of oxygen and nitrogen.

1400 lb. While this is not the whole story, a very careful analysis, based on experimental data, indicates this result as entirely possible.

"This has an important effect on the consumption of power, for obviously it will require only 67 per cent as much oxygen to burn 1400 lb. of coke as it does to burn 2100 lb., and we therefore reduce our power consumption by 33 per cent to burn the same quantity of coke in each case.

"This is not all. The above computation assumed a blast containing 50 per cent oxygen, which may be obtained by mixing pure oxygen, on which our power calculations are based, with 1½ times its volume of air, which costs nothing; this reduces the pure oxygen which must be furnished to about 73 per cent. The product of these two percentages, 67 and 73, is about 49 per cent, and it thus looks as though power consumption by this suggested process might actually be less than at present, to say nothing of the saving of gas for heating the stoves. It becomes then a question merely whether the saving of 1000 lb. of fuel would pay fixed charges on the new investment; this is obviously a question of locality rather than of possibility for the present.

"There are, however, several other sides to the subject. One is the increasing leanness of the ores available; this may perhaps be best illustrated by the fact that when my father was called on to make an examination of the Chaplin mine in 1891 he found them throwing 56 per cent ore over the dump as rock. The effect of increasing the leanness on fuel consumption has already been felt, and is destined to be felt much more distinctly in the future. Ore of 52 per cent Fe produces about $\frac{1}{2}$ ton of slag per ton of iron. Ore of 38 per cent Fe and 38 per cent silica produces 2.25 tons of slag, an increase of 1.75 tons, which at 0.4 ton coke per ton of slag produced means an increase of 0.7 ton in coke. In the same manner an ore with 25 per cent Fe, 48 per cent SiO_2, and 15 per cent Al_2O_3 would produce 5 tons slag per ton iron, which, at 0.4 ton of coke per ton of slag, would require 2 tons coke for slag alone, or nearly 3 tons in all.

"This would require 4.2 tons of coal per ton of iron, since to make 1 ton of coke takes 1.4 tons of coal, and the value of the by-products does not more than pay for coking.

"Moreover, we now use a large tonnage of ferromanganese and a considerable tonnage of ferrosilicon, which can be made only up to 15 per cent Si in the blast furnace; anything above this must be made in the electric furnace. In the case of ferromanganese, a heavy loss of manganese occurs because the bottom of the furnace is too cold and the top too hot. With both ferromanganese and ferrosilicon the consumption of coke is twice as much as with pig iron, though the heat requirements are but little greater. This is because the critical temperature at which the operation must be conducted is much higher. We can easily see by the chart that the critical temperature must be about 3300 deg. Fahr. to require this amount of coke, and that the available heat per pound of coke at this temperature, and with 50 per cent oxygen, is 2100 B.t.u., as against 800 B.t.u. with ordinary hot blast. In this case we may be sure that we could reduce the coke consumption to one-half with oxygen blast, and by reducing the volume and increasing the temperature of the slag we would cut down the slag loss of manganese; furthermore, the quick drop in temperature of the gases, due to their small volume, would prevent the volatilization of much of the manganese, which in present practice is being lost in that way.

"The critical temperature now attainable limits the production of ferrosilicon to those ferrosilicon brands containing 15 per cent or less Si, but a brief inspection of the chart will show that this will not be true when we use 50 per cent oxygen, and I confidently expect that we shall be able to make 50 per cent ferrosilicon in this way

"You may question the possibility of withstanding the high temperature produced by the combustion of incandescent carbon in oxygen, thinking that this will be a serious objection to the proposed process; no difficulty is to be anticipated on that score because we have no reason to expect any higher temperature with oxygen blast than we attain to-day. It must be remembered that the temperature of any combustion is determined by the total quantity of heat developed divided by the thermal capacity of the substances present. Theoretical combustion temperatures of the present blast furnace run up to 3500 deg. Fahr., but it is doubtful whether actual temperatures often exceed 2800 deg. or 2900 deg., because we charge the furnace with sufficient 'burden' to hold the temperature down to this point. With an oxygen blast, we should simply dampen the combustion with enough more burden to keep the temperature practically where it is now.

Other Applications

"The nitrogen discarded from the blast would be an asset of great value. Existing air distillation plants are run for the production of nitrogen for cyanamide, but the manufacture of ammonia by direct synthesis of hydrogen and nitrogen, without excessive power consumption, is an established fact; methods have also been developed for the production of hydrogen, both by partial liquefaction of water-gas or coke-oven gas, and by treatment of water-gas with lime. If this process be perfected we can obviously make about a pound of ammonia for every pound of iron, and at comparatively small expense. This would alter the fertilizer situation decidedly for the better.

"Many other dreams will be realized when we obtain really cheap oxygen. One of these is to obtain rich producer gas, containing a high percentage of the heating value of the coal, so that transmission of power and heat by gas generated at the coal mine will be not only feasible but profitable in many instances. To obtain water-gas by present methods, we must waste a large part of the heat value while 'blowing up' the producer, but having pure oxygen we could use a large quantity of steam with it continuously, thus producing a gas consisting wholly of hydrogen or hydrocarbons, and carbon monoxide, which would probably have a heat value of at least 500 B.t.u. per cubic foot and would afford a very high temperature of combustion because entirely free from nitrogen. By mixing a limited percentage of oxygen with city gas in the mains, its lighting power, applied to mantles, is enormously increased and it is not explosive.

"These are the phases of the subject with which I am most familiar. There are many others of almost equal importance, intimately connected with metallurgy and chemistry. Those who wish to be leaders in their particular branch of the profession would do well to ask themselves the question: 'What will probable developments in the production of cheap oxygen do for my field of chemistry or metallurgy?'"

Blue Vitriol.—Since June 1, 1915, the sale of copper sulphate, manufactured by the Nichols Copper Company, is handled exclusively by the General Chemical Co.

A preliminary report on the dye-stuff situation in the United States has been issued as Senate Document No. 952, Sixty-third Congress, and can be obtained free on application to the Senate Document Room, Washington, D. C.

Coal-tar products and the possibility of increasing their manufacture in the United States are considered in *Technical Paper* 89 recently issued by the Bureau of Mines, Washington. The paper contains also a chapter on coal-tar products used in explosives.

The production of chromium in the United States has increased since the war cut off European supplies. California is the chief source of chromium in this country. The production in 1913 was 255 long tons, and in 1914, 591 long tons. The gain in quantity was 131 per cent and in value 205 per cent.

The first ferromanganese furnace of the Noble Electric Steel Company at Heroult, Cal., was put in operation on June 3 and is reported to have produced a satisfactory cast of ferromanganese of 80 per cent grade, according to the British standard. This furnace has a capacity of 10 tons a day. Suitable ore, it is claimed, is supplied to the plant from mines in Mendocino County. The project is in the control of Mr. H. H. Noble, formerly president of the Northern California Power Company.

Vacuum Pans

Classifications, Principles, Tests

The paper by Prof. **E. W. Kerr,** assisted by J. F. Gunther and W. A. Rolston, on Performance Tests of Sugar-House Heating and Evaporating Apparatus, which forms Bulletin 149* of the Agricultural Experiment Station of the Louisiana State University and A. M. College, Baton Rouge, La., contains an interesting account of extensive vacuum-pan tests, made in large-

larger in diameter. There are several different arrangements of coil pans, a typical arrangement being shown in Fig. 4. Coil pans of this type may have single, double, triple or quadruple coils, as shown in Figs. 1 to 4 inclusive. Fig. 5 shows what may be called a manifold coil pan, there being an interior manifold for each set of coils, the steam entering the coils through the manifold and the condensation leaving from it. Fig. 6 shows another type which may be called the double manifold coil pan, steam entering the coils through one
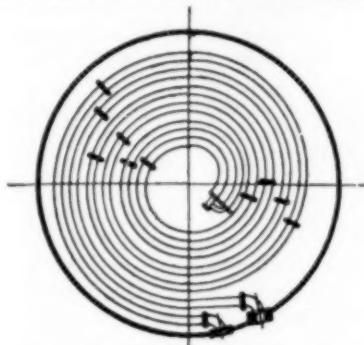
FIG. 1—COIL VACUUM PAN, DOUBLE COILS.
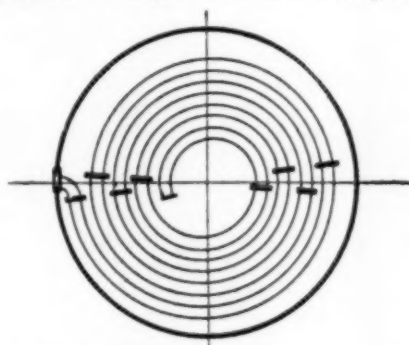
FIG. 2—COIL VACUUM PAN, SINGLE COIL
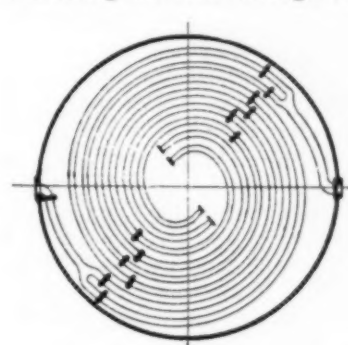
FIG. 3—COIL VACUUM PAN, QUADRUPLE COILS

scale sugar-house operation. A suggestive classification of vacuum pans is first given, with an explanation of the principles involved.

Classification

There are two general types of vacuum pans (Figs. 1 to 9)—namely, calandria and coil pans. A calandria

interior manifold and the condensation leaving them through another manifold.

Fig. 7 illustrates a plain calandria pan with two steam coils below the calandria. It will be noted that there is a central downtake as in standard evaporators, also a number of smaller downtakes nearer the circumference. Fig. 8 shows a calandria pan differing from the plain
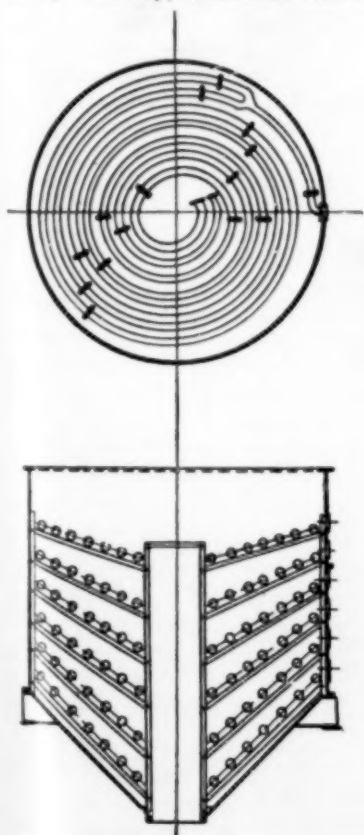
FIG. 4—COIL PAN, DOUBLE COILS
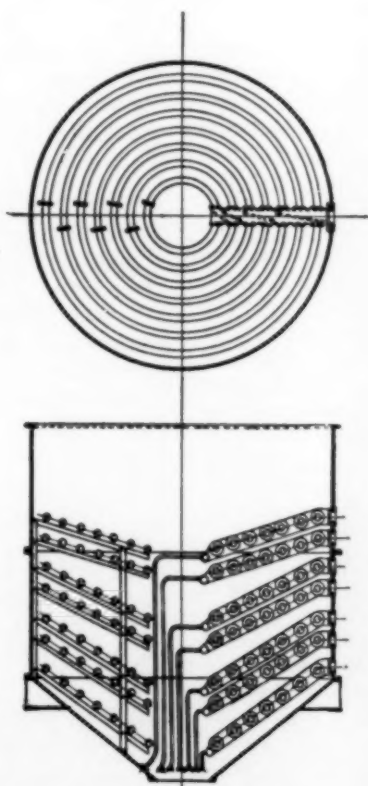
FIG. 5—MANIFOLD COIL PAN
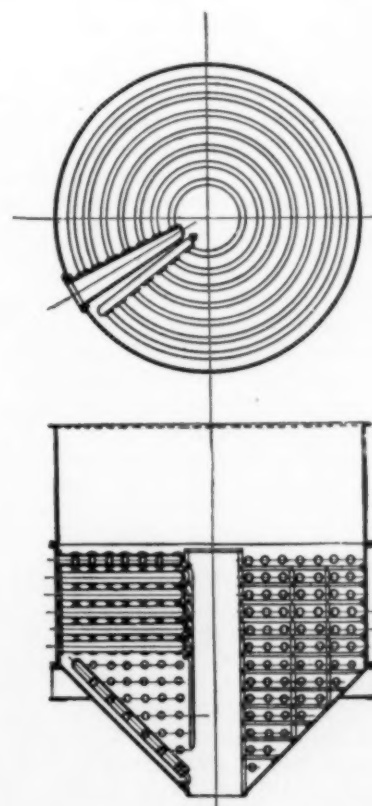
FIG. 6—MANIFOLD COIL PAN

vacuum pan in the simplest form is practically of the same construction as a standard vertical-tube evaporator, except that the tubes are somewhat shorter and

*An abstract of the contents of this Bulletin is given in the Synopsis in this issue.

calandria pan shown in Fig. 7, mainly in the fact that the tube sheets are inclined. Fig. 9 illustrates another pan similar to that of Fig. 8 except that the tubes as well as the tube sheets are inclined. There are various other arrangements of calandria pans though those il-

lustrated will serve to indicate the general principles involved in their design.

The factors which affect heat transmission and capacity in vacuum pans are in a general way similar to those in multiple evaporators. However, due to the difference in the arrangement and construction of the heating element, the methods necessary for meeting the requirements differ somewhat.

Principles Involved

TEMPERATURE FALL

In vacuum pans the temperature fall is generally much greater than in evaporators for the reason that the temperature difference between steam and liquid is not subdivided as in evaporators. In pans where live steam is used the pressure is usually 25 to 100 lb. gage, the average being in the neighborhood of 60 lb. gage, with a vacuum of 26 in. mercury. This would give an apparent temperature fall of 182 deg. This naturally results in a greater transmission of heat per unit of time and area than in evaporators. This applies especially to coil pans. In the case of calandria pans,
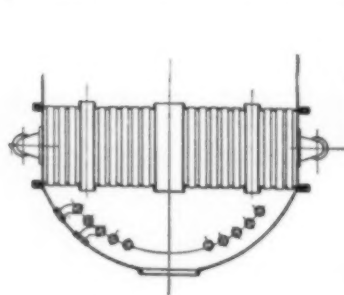
FIG. 7—CALANDRIA PAN.
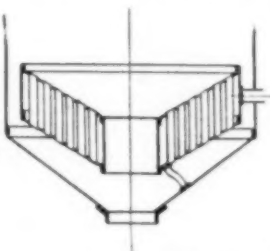
FIG. 8 — VACUUM PAN WITH INCLINED TUBE SHEETS

where more heating surface can be provided in a pan of given diameter than is possible with coils, exhaust steam can be and is often used instead of live steam. With exhaust steam the pressure will not be higher than about 10 lb. gage and the apparent temperature fall will be in the neighborhood of 100 deg. to 110 deg.

HYDROSTATIC HEAD

In vacuum pans the head is much greater than in evaporators. In a pan of average size the maximum head at the end of a strike is 12 ft. to 14 ft. above the lowest heating surface and a large part of the strike is boiled with average heads of 5 ft. to 8 ft. This, of course, results in a considerable increase of pressure and the temperature of boiling will be considerably higher than that corresponding to the vacuum in the pan. For this reason it is best to design vacuum pans with relatively large diameter and small height.

DENSITY AND PURITY OF THE LIQUID

In laboratory evaporator tests of Professor Kerr it was found that the density of the liquid also has a marked effect upon the rise in boiling temperature above the theoretical. For 70 deg. Brix, the rise about the theoretical was about 9.4 deg., with a vacuum of 25 in., referred to a barometer of 30 in. This curve was obtained with a sugar solution made up from a granulated white sugar, which was, therefore, practically pure— that is, with a purity of 100. The density of a strike varies from 50 deg. Brix at the beginning to about 95 deg. Brix at the end, so that the average Brix of a strike would be 70.

The purity of the liquid also affects the rise in temperature above the theoretical, the lower the purity the greater the rise. For Louisiana the purity of a strike of firsts will average something like 70, while for lower

products the purity will be 60 or less. Sometimes a crystallizer strike will have a purity of considerably less than 50. In the tropics the purity will be somewhat higher than these, a purity of 80 for a strike of first being common.

Fig. 10 gives curves plotted from figures given by Classen showing the relation of purity to temperature

FIG. 9—EXPRESS PAN, INCLINED TUBES AND TUBE SHEETS.

rise. From this it is evident that due to the high density and low purity alone the temperature rise above the theoretical will be more than 25 deg. and in addition to this there is an added increase due to hydrostatic head, making a total rise of 30 deg. or more for the maximum condition.

THICKNESS AND MATERIAL OF THE HEATING TUBES OR COILS

As a usual thing, the diameter of coil in coil pans is 3½ in. or 4 in. The tubes in calandria pans also are usually 3½ in. to 4 in. in diameter. On account of the increased diameter, also on account of the more or less violent vibration incident to ebullition, the tubes are thicker than evaporator tubes, being usually in the neighborhood of 14 gage, corresponding to a thickness of approximately 1/12 in. This will cause some reduction in the heat transmission.

The heating surface in both coil and calandria pans is greater heat transmitting quality, but because of its
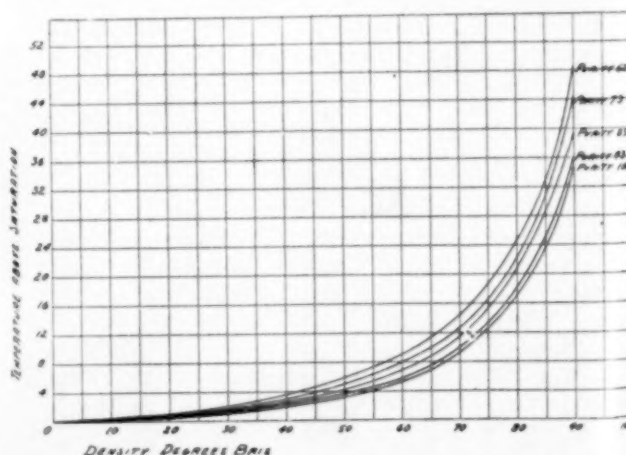
FIG. 10—EFFECT OF PURITY ON TEMPERATURE OF BOILING

ductility, which makes it easy to work. The latter is especially important in coil pans.

VELOCITY OF CIRCULATION OF THE BOILING MASS

As in evaporators, rapid circulation is very beneficial as regards heat transmission. Much can be done in designing pans that will aid in bringing about good circulation.

In calandria pans the same general principles hold as with standard evaporators. Generally there is a central

downtake and in some cases additional downtakes, as shown in Fig. 7. The inclined tube sheets shown in Figs. 8 and 9 also aid in producing defined paths of circulation, the liquid passing upward through the tubes at the outside and in the annular space at the circumference and downward at the middle.

In order to further define the path of circulation above the calandria, the Express pan, Fig. 9, is provided with a cylindrical false shell, strengthened by pipes, B, which tends to give a circulation as shown by the arrows. The liquid inside of the false shell rising from the heating surface is of lower density than that between the false shell and the shell, due to the high temperature bubbles of vapor it contains. This causes the liquid to overflow from the interior to the exterior of the false shell. It is said there are two separate circulations as shown by the arrows.

In coil pans the path of circulation is likely not to be so positive or well defined as in calandria pans and for this reason the coefficient of heat transmission may be greater in calandria pans than in coil pans. The circulation is upward between coils and downward through the downtake at the center, the diameter of the downtake being equal to the minimum diameter of the coils. In a 10-ft. coil pan of standard construction the downtake will be in the neighborhood of 30 in. in diameter.

The space between coils in horizontal directions af-

AIR IN THE HEATING COMPARTMENT

The presence of air in the heating compartment has the same detrimental effect whether in vacuum pans or in evaporators. Air enters with the steam, and, as the steam condenses, it will accumulate unless it is promptly removed. On account of the relatively high pressure in the heating compartment of vacuum pans, the loss in temperature fall due to the presence of air is small as compared with evaporators where the pressures are in most cases below that of the atmosphere.

In calandria pans the methods of removing air are practically the same as for standard evaporators, vents being required. In connecting the pump or trap which removes the condensation from the calandria it is important to arrange the piping in such manner that air pockets will not be formed.

In coil pans the air is removed along with the condensation from the lower ends of the coils by different methods which will be described under the head of condensation.

Where traps are used, resulting in practically no steam velocity at the lower ends of the coils, there will be a tendency for air to accumulate and to vent this air numerous devices have been employed.

One requisite for the prevention of air pockets in coils or in the piping is that there should be a gradual incline downward where the pipe runs full of water. As air

FIG. 11—DIFFERENT WAYS OF REMOVING CONDENSATION FROM VACUUM PANS; (a, BY AUTOMATIC RECEIVER PUMP; b, BY A SINGLE TRAP; c, WITH A TRAP FOR EACH COIL; d, WITH ADJUSTABLE CHECK VALVES)

fects the circulation also. In placing the coils one above the other the space from bottom to top should be as straight as possible, otherwise the resistance to the flow of liquid in a vertical direction will be great and the rapidity of circulation reduced. The supports of the coils may also interfere with the circulation if they occupy too much room and are improperly arranged.

In some coil pans a circulation is induced mechanically by means of a revolving screw placed in the vertical axis of the pan.

VELOCITY OF STEAM

As in evaporators a rapid flow of steam on the heating surface will increase the coefficient of heat transmission. In calandria pans the same principles hold in regard to steam velocity and distribution as in standard effects. As vacuum pans seldom use steam of pressure below that of the atmosphere, pumps for removing the condensation are not required, hence the flow of steam toward a pump, which is common in evaporators, is missing in calandria pans. In coil pans the velocity of the steam is high at the end of the coil nearest the entrance and is practically zero at the other end, provided no steam is allowed to leave the coil, as would be the case when traps or automatic receiver pumps are used for removing the condensation. However, when adjustable check valves are used and they are left open too much, there will be some flow of steam from the coil, which will result in increased heat transmission, though this will be at the expense of economy.

will rise in water, an air pocket will be formed at any high point unless the velocity is sufficient to sweep air bubbles along with the water.

CONDENSATION

As in all heating and evaporating apparatus vacuum pans must be promptly voided of the water of condensation or there will be a loss in the efficiency of the heating surface. The water of condensation may be removed from calandria vacuum pans by means of traps or automatic receiver pumps, either of which when properly installed and of the proper kind is satisfactory. The condensation from coil pans may be removed in a number of different ways as shown in Figs. 11, a, b, c, d.

Systems for handling condensation from heating and evaporating apparatus in sugar factories may be arranged according to two systems—namely, "closed" and "open." In the former the condensation is returned to the boiler as feed water without releasing the pressure —in other words, the boiler receives it at the temperature it had when leaving the pan or other apparatus. In the open system the water after leaving the pan or other apparatus is taken to an open receiver or hot well, from which it is pumped to the boiler. It is evident that as the pressure in the open receiver is that of the atmosphere, the temperature of the boiler feed taken from it cannot be higher than 212 deg. In vacuum pans the steam pressures are such that the temperature of the condensation may be 250 or more. When water with such high temperature is released in an open re-

ceiver a large amount of heat will pass off in the form of vapor when the pressure is released.

The arrangement shown in Fig 11a is well adapted for use with a closed system. The arrangement shown in Fig. 11b may also be used with a closed system, provided the trap is of the "return" type. In Fig. 11c separate traps are connected to the drain pipes for each coil, the traps being of the "non-return" type. In Fig 11d the removal of condensation is controlled by means of adjustable check valves. These valves are adjusted so that water but not steam will flow through. Evidently this arrangement could be used only with an open system.

On account of the occasional trouble due to the accumulation of air at different points in the system, to the disturbance caused by the mixing of condensation waters of different temperature, and to the fear that the feed pumps will not handle the water of very high temperature, there has been some objection to the use of closed systems. Practice, however, has shown that such systems are feasible and desirable,

Fig. 12 illustrates diagrammatically the feed water system used at the new Adeline sugar factory. There are four boiler feed pumps, three of which are of the automatic receiver type, the other without a receiver. There are two vacuum pans, the condensation from which is removed by two of these automatic receiver pumps. There are three raw juice heaters, though only two of them are in operation at one time, the third one being out for cleaning. One of these heaters operates with live steam and the other with exhaust steam. A large portion of the feed water naturally comes from these raw juice heaters. There are also two thin juice and two thick juice heaters, though only one of each is operated at one time under normal running conditions. Automatic receiver pump, number three, handles all of the condensation except that from the two vacuum pans. This includes condensation from the raw juice heaters, the thin juice heaters, the thick juice heaters, the steam engine separators, and the first bodies of the evaporators, also the drips from the high-pressure steam lines. Each of

FIG. 12—SYSTEM FOR HANDLING CONDENSATION AT ADELINE SUGAR FACTORY

provided they are designed and arranged along rational lines. Often a closed system is lacking only in the need of equalizing or flash connections for ridding the system of air and vapors. The feed pumps will take water no matter how hot it is, if the pressure in the suction main is sufficient. Consider the water from a vacuum pan with a temperature of 280 deg. This high temperature is that corresponding to a pressure of 65 lb. gage and this pressure will certainly force the water into the pump, unless the pump happens to be too small for the work, so that it has to run at an abnormally high speed. In systems of this kind it is of great importance to have pumps of liberal size so that they can handle the water at slow speed.

Hot water mixing with cold water in a feed water heater is likely to cause pounding and unsteady action in general. For this reason it is better to mix them in a receiver of considerable volume with some vapor space in the upper part of it. The vapors forming in the top of the receiver may be released into the exhaust mains or into some heater where the heat from them may be utilized. To release these vapors into the atmosphere would, of course, make an open system of it.

these different lines drain into a trap and the traps discharge through separate lines into the header above the receiver of pump number 3. The traps for the raw juice heaters are located on the ground floor below the level of the header, each trap having a live steam connection for discharging.

In order to provide for flash from the vapors coming from the condensation leaving the live steam raw juice heater a flash drum is provided as shown. The raw juice heaters are so connected that condensation from the exhaust heater can always be by-passed around the trap directly to the header. The condensation from the live steam heater passes through the relief valve into the flash drum and from there to the header, where it mixes with the condensation from other sources. From the top of this flash drum a flash connection is made to the exhaust steam mains. At one end of this drum there is an outlet with float-operated valve so that water cannot rise above a certain height in the drum. This prevents water from getting into the exhaust main. By means of this drum all disturbances of the kind mentioned above are prevented, the liberated flash being utilized along with the exhaust steam in the evaporators and other apparatus using exhaust steam. The make-up

feed water is handled by pump number 4, which draws from an open tank outside of the boiler room. The water in this tank is condensation coming from the second and third bodies of the evaporators. There is also an overflow into this tank from the header described above, which operates occasionally when the supply of condensation is greater than the boiler feed requirements at the time. This open tank in turn has an overflow into the sewer. The average temperature of feed water in this plant as found in a number of tests was about 216 deg. Fahr.

Fig. 13 shows another closed feed water system. In principle it is the same as that used at the Guanica Central in Porto Rico. In this case all of the condensation from different sources used for feed water is delivered to the boiler feed receiver, from which hand-controlled feed pumps deliver it to the boilers. The quadruple effects and the vacuum pans are situated some 40 ft. above the boiler feed receiver. From the top of the boiler feed receiver there is a vapor line connecting to the exhaust mains. In this line is a relief valve set at 15 lb. gage, so that there will be a pressure of 15 lb. gage in the receiver. The condensation from the vacuum pans is discharged by traps into an auxiliary closed receiver with a vapor connection to a feed water heater used for heating make-up feed water. The condensation is discharged by gravity into the boiler feed receiver. The con-

satisfactorily, the average temperature of the boiler feed being about 227 deg. Fahr. There are no air locks and the system runs very smoothly.

The removal of condensation is also affected largely by the design of the vacuum pans themselves. The inclined tube sheets of Figs. 8 and 9 facilitate prompt drainage, the water being taken off from the lowest point. In large pans of this type there are generally three or four outlets.

In coil pans the length and diameter of the coil and its inclination to the horizontal has much to do with its drainage. With a coil of given diameter and steam pressure the amount of water that can flow out at its lower end is limited according to hydraulic law. Since the carrying-away capacity is proportional to the diameter, and the condensing power proportional to the length, the ratio of length to diameter is a controlling factor. It has often been stated that this ratio should not exceed 200.

Naturally a coil with steep inclination will drain better than a coil less steep—in fact, the steepness of the coil depends upon the length of coil in a pan of given size, a short coil giving a greater inclination than a long coil, equal drops considered. By reference to Figs. 1 to 4, inclusive, it can be readily seen that with a pan of given diameter a single coil would have approximately twice the length of a double coil, and four times the length of a quadruple coil, the
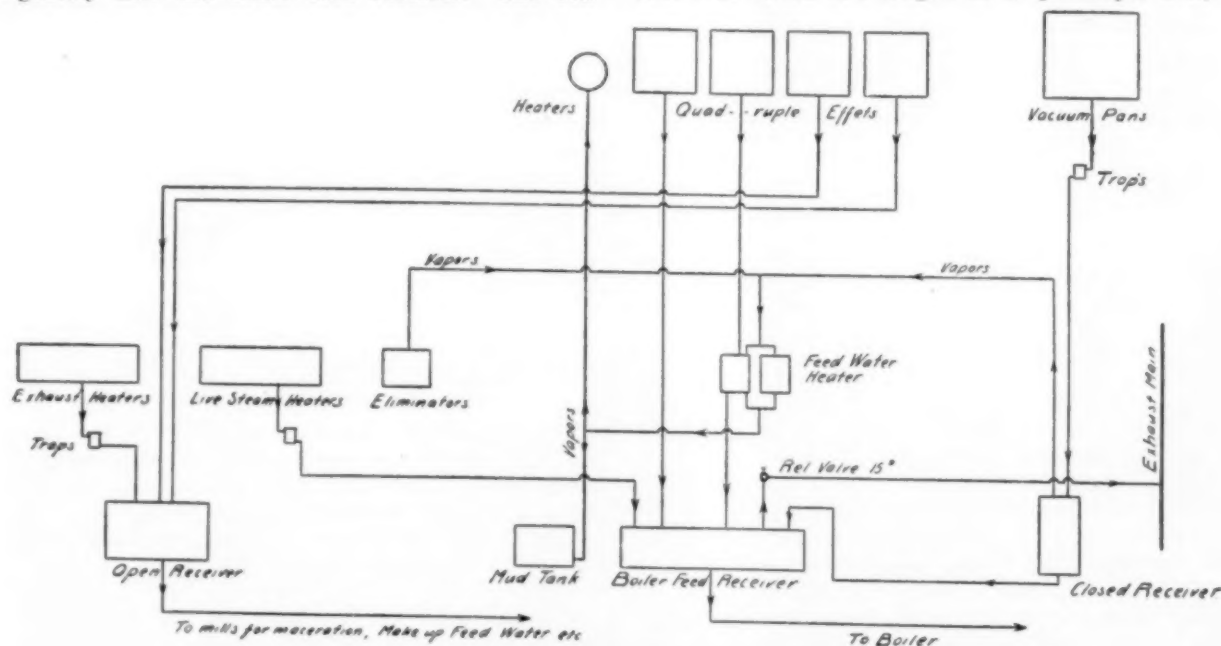

FIG. 13—SYSTEM FOR HANDLING CONDENSATION AT GUANICA CENTRAL

densation from live steam heaters is discharged by traps directly to the boiler feed receiver. As shown, the juice heaters using exhaust steam discharge their condensation by means of a trap to an open receiver. The pressure in the exhaust heaters is seldom much above atmospheric. The hot juice leaving the live steam juice heaters usually has a temperature of 220 deg.

On its way to the separators it is passed through eliminators, consisting in the main of closed drums with practically atmospheric pressure in them. The object of these eliminators is to remove and make possible the utilization of the heat in the juice above 212 deg. This heat passes off in vapors which mix with those from the auxiliary pan receiver and which are utilized in heating the feed water or in preheating juice just prior to the quadruple effects, also in heating scums in the mud tanks. This system works very

angle of inclination being greatest in a quadruple, less in a double and least in a single coil. In pans of average size double coils are most common, quadruple coils being used in very large pans and single coils in very small pans.

Occasionally triple coils are used, branching on the inside in the manner similar to that shown in Figs. 1 to 4. Figs. 1, 2, 4 show two types of outlets for double coils. In the former there are two separate outlets—in other words, there would be a total of 12 outlets. In Fig. 1 the two coils are brought together with a single outlet so that there would be a total of six outlets. On general principles the double outlet arrangement is to be preferred. In the attempt to arrange for shorter coils the manifold coil pans shown in Figs. 5 and 6 have been designed. In Fig. 5 each manifold inside of the pan is divided into four

parts, so that steam makes a circuit through three coils, then two coils, then two circuits of one coil each, the condensation being led off from the lowest point of each manifold. As shown in Fig. 6, there is a steam manifold and a condensation manifold for each set of coils. The steam makes one circuit, no circuit being greater than the length of one coil.

DISTRIBUTION OF STEAM

Calandria vacuum pans differ from standard effects in that they seldom have circumferential distribution of steam. The steam is usually delivered directly to the tubes by the steam pipe which enters at one side. In very large pans the steam may enter in two pipes on opposite sides of the calandria. In coil pans the steam distribution depends entirely upon the location of the coils, the diameter of the coils and their distance apart. Naturally a better distribution can be obtained by making the coils small.

Some years ago a number of pans were built with two-inch coils, the spacing between coils being about two inches also. This was found to be an advantageous arrangement as regards heat transmission, but very objectionable as regards voiding the pan. With very stiff masscuite the pan could not be voided.

In modern coil pans in which the coils are usually 4 in. in diameter the spacing is generally about equal to the diameter of the coils—that is $3\frac{1}{2}$ to 4 in.

FACTORS AFFECTING ECONOMY IN VACUUM PANS

The heat efficiency of vacuum pans depends altogether upon the loss due to radiation. However, the weight of steam required per unit weight of water evaporated is affected by the following factors:

Loss due to radiation.

Temperature of the syrup entering.

Pressure of the steam.

Temperature of condensed steam leaving.

In all vacuum pans the heating elements are surrounded by the boiling liquid which has a relatively low temperature—that is, the temperature corresponding to the vacuum under which the boiling takes place. The temperature drop from inside to outside is, therefore, small, hence the radiation loss should be small.

The amount of this loss will, of course, depend upon whether the radiation surfaces are covered with heat insulation or not and upon the kind of covering used. An approximate calculation of Professor Kerr shows 0.6 per cent loss for a 10 ft. coil pan boiling under normal conditions without covering, 0.15 per cent when entirely covered and 0.36 per cent with the cylindrical part of the shell covered, the dome and catch-all being uncovered. In each case the loss is based on the total heat delivered in the steam.

Naturally the radiation loss will be less for a strike of given size when it is boiled quickly than when boiled slowly. For this reason pans are usually less efficient from the heat standpoint when boiling low grade products than when boiling high grade products. Calandria pans with their greater amount of heating surface and more rapid circulation should be more efficient thermally than coil pans because of the shorter time required to boil.

The work of a vacuum pan consists of two parts—namely, heating the entering syrup up to the boiling point and evaporating. Naturally the lower the temperature of the syrup entering the more steam will be required for heating it up to the vaporization point.

The pressure of the steam and the vacuum affect the weight of steam required per pound of water evaporated due to the effect of latent heat. For example, assume a steam pressure of 60 lb. gage with corresponding latent heat of 899 and a vacuum of 26 in., with corresponding latent heat of 1026. In this case $1026 \div 899 = 1.085$ lb. of steam will be required to evaporate 1 lb. of water from the juice in addition to that required for heating. With high steam pressure a larger weight of steam would be required due to the reduced latent heat, and vice versa.

In calandria pans there may be a small loss in venting the incondensable gases, though this will be practically negligible. In coil pans there may be a considerable loss due to leakage of steam, especially where check valves are used and the steam is allowed to blow through to the atmosphere. Pan operators like to do this, because the current of steam thus set up in the coils results in increased heat transmission and capacity. It is evident, however, that this can be done only at the expense of economy. The same result may be brought about by leaky traps. It has been found in practice that much attention has to be given to traps to prevent the valves from leaking, especially if they are not of the best construction. Unfortunately, it is difficult to determine these leakage losses by tests for the reason that the steam thus lost cannot be measured, the steam consumption being determined by weighing the condensation. If the condensation is removed immediately after it forms, its temperature will be practically the same as that of the steam before it condenses. If it remains any length of time after condensing, its temperature will be reduced and this will result in decreased steam consumption for a given amount of evaporation.

Tests of Vacuum Pans

A very extended series of tests were made by Professor Kerr and his co-workers with a view of obtaining data regarding heat transmission and economy under regular operating conditions, for different types of pans, with varying grades of product. Twenty-three pans were tested in all. As to the arrangement and details of the tests the reader must be referred to the original publication. (An interesting account of a vacuum pan test of this kind with heat balance was given in an article specially written for this journal by Professor Kerr, in our issue of February, 1914, Vol. XII, p. 81.)

COEFFICIENT OF HEAT TRANSMISSION

The capacity of a given vacuum pan will depend upon the coefficient of heat transmission, the time the heating surface is on in per cent of the total time of boiling the strike and upon the temperature fall, the latter being affected materially by the increase of boiling temperature due to head and density, etc., which has been discussed.

The ability of the heating surface to transmit heat from steam to boiling liquid is directly proportional to the coefficient of heat transmission. It was calculated by dividing the total heat transmitted by the actual temperature difference and by the average time the total heating surface was working. The actual temperature fall was obtained by subtracting the temperature of boiling from the temperature of the steam.

In making the tests careful data were kept regarding the time when steam was turned on each coil, so that the actual time each coil was working could be estimated. The sum obtained by adding the time the coils operated, divided by the number of coils, gave the average time the total heating surface operated. This divided by the time of a strike and multiplied by 100 gave the actual time of the total heating surface in operation in per cent of the total time of the test. Evidently it would not be fair to charge the heating surface with the total time of the strike. The average time the total heating surface was on varied from 56 per cent to 83.9 per cent of the time of the strike, the average being 76 per cent.

This shows the great variation in capacity which may result from different methods of handling steam in the different coils as practiced by different sugar boilers.

Figures are given of the apparent and actual weight of water evaporated per square feet of heating surface per hour, the apparent weight being based on the total time of the strike in each case, and the actual weight on the actual average time the heating surface was working. The apparent weight of water evaporated varied between 6.48 and 20.35 lb. per sq. ft. per hour, the actual weight between 9.55 and 27.3 lb. But even the actual weights of water evaporated are not a fair unit for comparison because the steam pressure and the vacuum varied in the different tests. Thus, after all, in these tests the coefficient of heat transmission is the only fair and absolute measure of the heat-transmitting ability of the heating surface.

The figures for the coefficient of heat transmission (in B.t.u.'s transmitted per square foot of heating surface per hour per degree Fahrenheit difference in temperature of the two sides of the heating surface) varied in the different tests between 45 and 174.8. The average coefficient for the coil pans with straight strikes, omitting tests 19 and 20, is 110, varying from a minimum of 76.28 to a maximum of 174.8. The average time since cleaning was three days—in fact, in nearly all cases the heating surface may be considered to have been in fairly good condition. The best three tests on coil pans—namely, 21, 22 and 23—gave coefficients of 134.5, 124.3 and 174.8 respectively—in fact, these were much higher than the others and raised the average considerably. Without them, the average coefficient would have been 95. These three tests represent the three principal methods for removing condensate—namely, check valves with single trap, automatic receiver pump and adjustable check valves. The high coefficients obtained with these different arrangements show that either of them when properly installed and operated will give good results.

The highest coefficient, 174.8, was obtained with the shortest average length of coil—that is, with a ratio of 118. Doubtless this has much to do with the fine result obtained. Tests 21 and 22 also were made on pans with relatively short coils, which were well drained and in which the heating surface was clean. With so many varying conditions, the effect of some of which it was impossible to measure, it is impossible to form definite conclusions as to the varying results obtained in the different tests. The highest ratio of length to diameter of coil was 294. Although there is no definite relation between this ratio and the coefficient of heat transmission it is evident that the length of the coil had much to do with the variation of the coefficients obtained.

Tests 1, 2 and 3, giving heat transmission coefficients of 111, 88.3 and 45 respectively, were made with straight, mixed and crystallizer strikes with greatly varying purities and give some very conclusive and interesting data regarding the effect of varying kinds of product upon the coefficient, since these three tests were made upon the same pan and under conditions practically the same.

TEMPERATURE OF BOILING

The increase of boiling temperature due to hydrostatic head, density of liquid, and purity of liquid, has been discussed before. In these tests the temperature rise varied from a minimum of 11.9 to a maximum of 27.5 deg., the average being 19.7 deg. The minimum rise was obtained with the Express pan (Fig. 9), and the maximum with a 10-ft. coil pan. The average temperature rise in the three tests on the Express pan was only 12.9 deg., which is considerably less than that obtained in the coil pans. This is doubtless due to the reduced height of pan, also to the better circulation. At the beginning of a strike both the hydrostatic head and the density were smaller than at the end of the strike, there being a gradual increase from beginning to end. Naturally, therefore, the temperature rise of the boiling point increases toward the end of the strike.

Curves given in a diagram of the report show very clearly the effect of purity upon the temperature rise, the rise at the end of the test being 20.5 deg. for the straight strike, $27\frac{1}{2}$ deg. for the mixed strike and 31 deg. for the crystallizer strike. The capacity of a pan decreases with the purity, not only because of the low coefficient of heat transmission, but because of the reduced temperature fall due to rise of the boiling point as well. In each of the curves there is a gradually increasing distance between the curve representing temperature of boiling and that representing temperature corresponding to vacuum.

COIL VS. CALANDRIA PANS

From the data given in the report it will be seen that the average coefficient of heat transmission in the Express pan tests was 40 per cent greater than the average coefficient in coil pans. The rise in temperature of boiling due to hydrostatic head, density and purity was also shown to be less in an Express pan than in the coil pans, which is also an advantage in that the smaller the temperature rise the greater the temperature fall for a given steam pressure. This means, of course, that there is a corresponding increase in capacity.

It may be well to state also that the amount of heating surface in the Express pan tested could be doubled by placing another calandria above the existing one. This, however, would require increasing the height of the pan.

The greater coefficient of heat transmission in the Express pan is doubtless due to the more rapid circulation and the more efficient removal of condensation, the latter being due partly to the sloping tube sheets and inclined tubes.

The test on the plain calandria pan shows a coefficient of only 58.38, which is very poor. This test was made with good syrup, but with steam having a pressure only slightly above that of the atmosphere. The reason for the very low coefficient is probably in the fact that the calandria was not properly voided of condensation. The condensation was removed by means of a steam pump; the outlet for condensation was $1\frac{1}{2}$ in., though this was reduced to $\frac{3}{4}$ in. This is evidently too small. For these reasons the results of this test can not be taken as representative of the type.

RATE OF VAPOR FORMATION

Designers of vacuum pans and accessory apparatus frequently need information regarding the rate at which vapor is formed in vacuum pans during different intervals of time in the boiling of a strike. Such data are of especial value in calculating the dimensions of condensers and vapor pipes. Some tests were made with this problem in view.

At first thought it would seem that the rate of steam condensation would be sufficient for this purpose. It should be remembered, however, that part of the steam condensed is used for heating and a curve plotted with time against rate of steam condensation might not have the same shape, as one with time plotted against water vaporized.

In order to determine the weight of water evaporated during successive time intervals of a strike it was found necessary to measure the weight of the hot well water. This was done by means of a weir in connection with a Hook gage. Knowing the weight of water for each successive interval of time the heat delivered to it during that time could be determined from its initial and final temperatures. This, divided by the heat of vaporization corresponding to the vacuum in

the pan for that interval, gives the weight of water evaporated.

This method was carried out in one test and the result, plotted diagrammatically, shows that for all practical purposes it may be assumed that the rate of vapor formation is proportional to the rate of steam condensation. As the curve in question is practically a straight line, the rate of steam formation during successive intervals is practically the same as the average rate—in other words, the velocity of vapors in a coil pan may be assumed to be the same at all times during a strike.

HEAT BALANCE

Finally the steam consumption was measured in eight of the tests and the heat balance determined for the same tests. There is some uncertainty in the heat-balance calculations on account of the fact that the figures for specific heats of sugar solutions, used in the calculations, are uncertain. The total heat entering, minus the heat leaving in the condensed steam is termed the "available heat." The heat actually used in evaporation, divided by the available heat and multiplied by 100, is designated as efficiency.

The efficiency figures vary from 90.9 to 96.95 per cent, with the exception of one test in which it comes out as more than 100 per cent. The results of these tests do not show any difference in economy for coil and calandria pans.

It was thought that the temperature of the condensed steam leaving might be nearer that of the steam in calandria pans than in coil pans. Observations, however, seem to show practically no difference in this respect.

An average from three tests on the Express pan showed a temperature of condensate 15.3 deg. lower than that corresponding to the steam pressure. The average temperature of condensate from coil pans was 16 deg. less than that corresponding to the steam pressure and varying from 11.7 deg. to 21.3 deg.

Vanadium from Oxide to Steel

BY WARREN F. BLEECKER AND WALTER L. MORRISON

The ores from which ferrovanadium is produced and the processes of extracting the vanadium salts and oxides therefrom are so generally known that it is unnecessary to discuss them here. They are only of importance in determining the cost of raw oxides or vanadium salts and the cost in every case would be independent of the method of reduction.

The processes of making ferrovanadium from the raw salts and oxides are limited, and there are but two known reducing agents which may be used for the production of ferrovanadium on a commercial scale: aluminium and silicon.

Aluminium is the one most used and is the less desirable. Any process wherein aluminium is used as a reducing agent for vanadium is but a variation of the Goldschmidt thermit process.

When the aluminothermic process is carried on strictly as an exothermic reaction, there is one certain evil, and the choice of one of two others. First, the quantity of aluminium necessary for reduction is much greater than the theoretical amount. Secondly the recovery of vanadium will either be low or there will be found too much aluminium in the resulting alloy. A further objection to this process is that there is no opportunity for refining the alloy, in case there are objectionable elements present.

These difficulties may be done away with by carrying the reaction on in an electric furnace. The raw oxide or vanadate may even be partially reduced with carbon before the final treatment with aluminium and by properly treating the reduced alloy with slags, the refining may be carried to any required degree. It is, of course, understood that if the impurities are base metals there is no hope of removing them in the electric furnace.

The better process of making ferrovanadium is by reduction with silicon. Silicon may be had at a cost of about one-third that of aluminium and its theoretical oxygen value is higher by 25 per cent. In heat units the advantage is with aluminium.

The reaction between vanadium pentoxide and silicon is not quite self-propagating. In the electric furnace, however, the reaction is very brisk and very satisfactory.

As with aluminium, it is not possible to obtain at the same time and in one operation a high vanadium recovery, high silicon efficiency and a low silicon content in the resulting alloy. In two electric-furnace operations these three very desirable conditions may be had at a very small additional expense. We have never succeeded in doing this in one operation, although if an alloy containing 4 or 5 per cent of silicon were desired only one operation would be necessary.

In the commercial application of vanadium to steel there are several factors which determine the cost and to a large extent the cost of the contained vanadium in steel determines what classes of steels will stand the expense of the vanadium addition.

The important factors in determining the cost of vanadium per ton of steel is as follows:

The cost of the raw ore per pound of vanadium contained.

The cost of the raw oxide per pound recovered.

The grade and character of the raw oxide.

The cost of reduction per pound of vanadium recovered.

The efficiency of the reduction process.

The efficiency of the alloy added to steel.

In our present discussion we are not concerned with the first two items. They are of the utmost importance, but they are constant factors whatever the subsequent procedure.

The grade and character of the raw oxide is important, because, as will appear later, the presence of base metals, such as iron, will be a source of greater expense in one case than in the other.

The efficiency of the aluminium thermit process is known only to those who are using it on a large scale. The best we have been able to do under the most favorable conditions, and using a good grade of oxide, is around 70 per cent recovery. Under these conditions there will remain in the finished alloy between 1 and 2 per cent Al.

Using the electric furnace the efficiency may be raised to 90 per cent recovery with 1.2 lb. Al per lb. V recovered. The resulting alloy will contain what we call a trace of aluminium, under 1 per cent carbon and less than 2 per cent silicon.

Using silicon as a reducing agent, the efficiency will be about 85 per cent recovery, with 1.25 lb. Si per lb. V recovered. The resulting alloy will contain less than 0.30 C., trace of aluminium, and 4-5 per cent Si. This silicon may be brought under 1 per cent by a second operation.

The reduction cost per pound V recovered we are at present not at liberty to divulge, but with furnace upkeep, electrode consumption, energy, fluxes, labor, overhead, etc., while very heavy, it still allows a very great saving over processes of reduction in which electric energy is not used.

The recovery of vanadium from ferrovanadium to finished steel castings probably averages 70 or 75 per cent.

If we assume all of the above data to be correct we may arrive at the average recovery from the raw oxide to the steel and knowing the market price of vanadium we may determine the cost per pound V in steel.

Taking the average efficiency of silicon reduction by multiplying by 0.75, we arrive at the value 63.75, which means that the higest recovery we may expect is in the low sixties.

This value further means that a pound of vanadium in steel requires one and two-thirds pounds of vanadium as oxide, and at a value of $2 per pound as alloy, costs $2.66.

Vanadium pentoxide contains 56 per cent metallic vanadium. One pound of vanadium in steel, therefore, required 2.96 lb. of oxide, which 15 per cent was lost in reduction, and over 20 per cent lost in the addition to steel.

It is evident, therefore, that if vanadium oxide could be added directly to steel, with a high efficiency, the cost of reduction and the loss in efficiency might be greatly reduced with a benefit to both the alloy manufacturer and the steel maker.

Vanadium may be introduced directly into steel, cast iron or any ferrous alloy from the pentoxide. The method of doing this is very simple and economical, and as will be seen by referring to the analytical data the recovery is excellent.

If a quantity of a vanadium compound, such as calcium vanadate, be thoroughly mixed with a small quantity of iron scale and sufficient silicon to allow an excess of 10 per cent above the theoretical quantity, there will result a mixture, which when added to molten steel, will introduce vanadium into steel efficiently and without appreciable segregation.

Any vanadium compound may be used instead of calcium vanadate and aluminium may be used instead of silicon.

Upon further consideration of this reaction several very desirable advantages will be apparent.

Although, as stated above, the reaction between vanadium pentoxide and silicon is not self-propagating, it is exothermic. The only heat necessary, therefore, is that required to fuse the lime which is added to insure a complete separation of the reduced vanadium from the resulting slag. The addition of vanadium in this manner, so far as chilling the metal is concerned, is equivalent to adding alloy in the molten state.

It is possible in this manner to provide an additional agent of absolute uniformity, not only in grade, but in composition as well.

This exothermic mixture may be added to all classes of ferrous metals at any stage, with the assurance that the vanadium will be effective and will be uniformly distributed throughout the metal.

The electric furnace is particularly useful in carrying on this reaction, the recovery being as nearly perfect as it is possible to hope for.

It is not necessary to carry on any subsequent slagging operations and the vanadium mixture may be added without removing or otherwise disturbing the slag or any other normal working condition.

In certain alloys, as with many crystalline substances, the solution takes more readily at the time of the formation of the compound than after the compound has cooled and assumed a solid state. This condition apparently exists upon addition of the exothermic vanadium mixture to steel, with the result that a high vanadium recovery and a uniform distribution of vanadium takes place.

The melting point of vanadium alloys varies with several things outside of the vanadium content. The presence of carbon raises the melting point rapidly, while alminium and silicon tend to lower it.

In adding this exothermic vanadium mixture to the open hearth, the amount of silicon can be increased to take care of the iron oxide. In this case the iron oxide may be wholly or in part omitted from the mixture, since the function of this material is to afford a medium in which the vanadium is instantly soluble—otherwise the reduction would be very incomplete and the recovery low. The oxide of iron is simultaneously reduced and a very rich vanadium alloy is formed, which is further dissolved throughout the molten steel.

On the other hand, in crucible melting the quantity of silicon may be decreased on account of the highly reducing conditions which exist at the time of the addition.

An examination of the results obtained when treating cast iron will reveal the fact that the reaction begins at a relatively low temperature.

Some interesting results were obtained while experimenting with aluminium as a reducing agent in the exothermic mix.

The reaction proceeded with more violence than when silicon was used, as might have been predicted. The resulting slag, which was high in alumina, was not sufficiently fluid at the temperature of the molten iron and consequently did not allow the vanadium to act as efficiently as it would otherwise have done.

The metal was poured from the cupola into a 600-lb. ladle, the alloy added and the iron poured. The metal to which the aluminium was added purged badly from every flask, large and small. The plain metal did not purge, nor did that to which the silicon mixture was added.

The addition of vanadium to cast iron in the ladle did not seem to give the castings any additional strength or other desirable properties, although no physical tests were made upon the bars.

Vanadium added to cast iron melted in the electric furnace, the silicon mixture being used, gave the bars a very dense structure, while the strength and hardness were apparently unaffected. No tests were made beyond breaking the bars.

MATERIALS

The following materials were used in making the exothermic mixes:

Calcium vanadate,	24.3	per cent	V_2O_5
Vanadium oxide,	83	per cent	V_2O_5
Iron scale,	70	per cent	Fe.
Aluminium,	99	per cent	No 30 shot.
Silicon,	85	per cent	Si.
Lime,	85	per cent	CaO.

Mix A.

        10 lb. calcium vanadate.
        4.7 " aluminium.
        10 " vanadium oxide.
1 oz. mix = 0.243 oz. V, or 0.0152 lb. V.
1 lb. mix = 0.243 lb. V.

Mix B.

        10 lb. calcium vanadate.
        9.2 " silicon.
        10 " vanadium oxide.
1 oz. mix = 0.206 oz. V, or 0.0128 lb. V.
1 lb. mix = 0.206 lb. V.

Mix C.

        100 lbs. iron scale.
        21.4 " silicon.
1 lb. mix = 0.573 lb. Fe, or 9.2 oz. Fe.

The following steels were made in a small arch furnace lined with magnesite. In each case the boiler punchings were used, these being melted under a neutral slag.

The chromium was added as 60 per cent ferrochromium, the silicon as 85 per cent ferrosilicon and the manganese as 50 per cent ferromanganese.

With but one or two exceptions the steels poured quietly, without purging and the castings were apparently solid.

The vanadium mixture should be added to the electric furnace just before pouring into the ladle in order to get the best efficiency. In pouring larger quantities of steel it is probable that the vanadium could be added in the ladle, although if added in the furnace we are more certain of avoiding segregation.

In case the vanadium silicon mixture does not contain iron oxide, segregation takes place to such an extent that the analyses are not dependable.

100 lb. steel, 5 lb. chromium, 1 lb. 15 oz. silicon, 6 oz. ferromanganese, 4 oz. ferrosilicon, with 19 oz. Mix B and 7 oz. Mix C, yielded steel A 800, containing 0.36 V, 1.19 Si, 1.53 Cr, and 0.70 Mn.

100 lb. steel, 4 oz. ferrosilicon, 6 oz. ferromanganese, 1 lb. 10 oz. ferrochromium with 19 oz. Mix B and 7 oz. Mix C yielded steel A 803, containing 0.08 V, 0.09 Si, 0.92 Cr, and 0.18 C.

100 lb. boiler punchings, 4 oz. ferrosilicon, 6 oz. ferromanganese, with 19 oz. Mix B and 7 oz. Mix C yielded steel A 804, containing 0.20 V, 0.07 Si, 0.10 Cr. and 0.19 C.

100 lb. steel, 1 lb. nickel, 5 oz. ferrosilicon and 4 oz. ferromanganese, with 19 oz. Mix B and 7 oz. Mix C yielded steel A 806, containing 0.08 V, 0.28 Si, and 0.25 C.

50 lb. steel with 11 oz. vanadium-aluminium-thermit (0.3 V) (thermit in cartridge) yielded steel A 1086, containing 0.29 per cent V.

100 lb. steel, 1 lb. silicon (50 per cent), ½ lb. manganese (80 per cent) and 19 oz. Mix B gave A 1193, containing 2.4 per cent Si and 0.29 per cent V.

100 lb. steel turnings, 1 lb. silicon (50 per cent), ½ lb. manganese (80 per cent) with 19 oz. Mix B and 7 oz. Mix C gave A 1195, containing 1.10 per cent Si and 0.28 per cent V.

100 lb. boiler punchings, 3 lb. 12 oz. nickel, 6 oz. ferromanganese, 4 oz. ferrosilicon and 1 lb. 13 oz. ferrochromium, with 19 oz. Mix B and 7 oz. Mix C, gave A 794, containing 1.32 per cent Cr, 0.20 per cent C and 0.33 per cent V.

100 lb. steel, 6 oz. ferromanganese, 4 oz. ferrosilicon, with 19 oz. Mix B gave A 798 containing 0.22 per cent V.

100 lb. boiler punchings, 4 oz. ferrosilicon, 6 oz. ferromanganese, with 10 oz. Mix B, and 7 oz. Mix C and 1 lb. 10 oz. ferrochromium (67 per cent Cr.) gave A 802 containing 1.31 per cent Cr., 0.22 per cent C, 0.19 per cent Si, and 0.23 per cent V.

50 lb. cast-iron scrap, with 8 oz. Mix B and 4 oz. Mix C, gave A 1090, containing 0.09 per cent V.

50 lb. cast-iron scrap, with 8 oz. Mix B and 4 oz. Mix C gave A 1091, containing 0.11 per cent V.

50 lb. cast-iron scrap with 4 oz. Mix B and 2 oz. Mix C gave A 1088, containing 0.23 per cent V.

50 lb. cast-iron scrap with 4 oz. Mix B and 2 oz. Mix C, gave A 1089, containing 0.18 per cent V.

Cast-iron bars made at Washington, Pa.:

A 1092	0.048% V	2.14% Si
A 1093	0.032	2.32
A 1094	0.027	2.26
A 1095	0.03	2.11

Charges A-1088 and A-1089 were made in the electric furnace and the vanadium added before pouring the cast iron into the ladle. It will be seen in this case that the efficiency is very high.

The samples A-1092 to A-1095, inclusive, were the result of adding the vanadium mixture to cast iron in a 600-lb. ladle, as the metal came from the cupola. It will be seen that while the efficiency is very low the temperature of the cast iron was sufficient to ignite the vanadium mixture and cause the reaction to proceed.

It must be concluded that vanadium may be added to steel, in the form of oxide, when mixed with a proper reducing agent and slagging elements.

It is further apparent that this process will result in the saving of the cost of reducing the vanadium in the production of the ferro-alloy.

Starting with a given quantity of oxide, we may expect, by this process, to find more vanadium in the steel than in case we introduce the intermediate step of making ferrovanadium.

American Electrochemical Society

The San Francisco meeting of the American Electrochemical Society will be held from Thursday to Saturday, Sept. 16 to 18, 1915. Friday, Sept. 17, will be devoted to joint sessions in the morning with the American Institute of Mining Engineers and in the afternoon with the American Institute of Electrical Engineers.

American Chemical Society

The next meeting of the American Chemical Society will be held at Seattle, Wash., from Monday to Thursday (Aug. 30 to Sept. 2). The schedule of the special train was given on page 419 of our July issue. The headquarters at Seattle will be at Hotel Frye, corner Third avenue and Yesler Way.

On Monday night, August 30, the council dinner will be held.

On Tuesday morning the first session will be opened by an address of welcome by Henry Suzzalo, president of the University of Washington, followed by the response by Charles H. Herty, president of the American Chemical Society. Dr. Leo H. Boekeland will then lecture on Chemical Industry, and Dr. H. K. Benson will speak on Industrial Resources and Opportunities of the Pacific Northwest.

In the afternoon the symposium of the Industrial Division, devoted to the influence of chemistry in various industries (which had been begun at the New Orleans meeting) will be completed. Papers will be presented by G. W. Sargent and A. S. Cushman, on iron and steel; by Alvis von Isakovics and E. T. Beiser, on perfumery; by G. W. Thompson, on lead; by Maximilian Toch, on paints and varnishes; by David T. Day, on petroleum, and by Sidney Mason on illuminating gas. A symposium will also be held on wood distillation.

In the evening a complimentary smoker will be given by the Seattle Commercial Club.

On Wednesday division meetings will be held during the day, and in the evening Dr. Charles H. Herty will present his presidential address.

For Thursday an excursion on Puget Sound is scheduled, and for the evening a subscription dinner.

The **Tyneside Alloys Co., Ltd.,** is a new British company operating at Pelaw, Newcastle-on-Tyne, for the manufacture of tungsten and molybdenum powders. The plant is open to purchase and treat all kinds of stanniferous tungsten ores and leady bismuth-molybdenum ores. The plant is under the management of Mr. William Jones, who formerly represented Mr. John Hays Hammond in Brazil.

Blast-Furnace Plant Auxiliaries and General Arrangement

BY J. E. JOHNSON, JR.

(Concluded from page 439)

The General Arrangement of Furnace Plants

In early days blast furnaces were very generally built singly, plants of two were scarce, and a greater number than that in charcoal practice were almost unknown. But as the world's consumption of iron has gone up the number of furnaces per plant has increased almost as rapidly as the tonnage per furnace, there being two in the United States with eleven, many of six and seven, and probably only a small portion of the total furnaces are single furnace plants. This fact has modified the general design of plants fundamentally. It is obvious that when a furnace stands alone the different elements of the plant as a whole may be arranged in almost any relation to one another, but when two or more are grouped together it is plain that their raw materials should come in by a means of transportation common to all, and that their output should be similarly taken away. Also that labor can be saved by grouping certain components of the equipment of each furnace together, notably the blowing engines, boilers and stoves. The first two can be supervised by the same men, and the third sometimes is. In considering the arrangement of furnace plants, therefore, we need scarcely to consider plants of less than two furnaces, because as stated above the equipment of the single furnace can be arranged in almost any reasonable way and meet the conditions fairly well.

On account of the enormous quantities of materials handled it is obvious that the best possible arrangement of the railroad tracks must be at the basis of any proper design, and all multiple furnace plants for many years past have virtually had the stock houses for all the furnaces in common, all being served by the same set of tracks. These for obvious reasons are made straight except in rare circumstances, and should always be so. This virtually forces the furnaces to be built in a straight line parallel to these stock house tracks.

The next points in the design involving the handling of a heavy tonnage of material are the casting arrangements and the cinder pits, and here it took us many years to reach a sensible design. Probably the greatest defect of all our designing is a tendency to put every part of the design either at right angles with or parallel to the next element, and plants have in general been laid out with their parts at right angles with or parallel to the other parts. The fact which seems to have escaped observation is that railroads do not run around right angles, and therefore with one part of the plant at right angles to another if the first were parallel with the tracks, the second must be at right angles to them, and therefore relatively inaccessible. In spite of this the line of the cast house was for many years built at right angles with the line of the stock house tracks, and in order to bring cars alongside the cast house to permit the direct loading of pig iron these tracks all had to make a sharp right angle turn. What is even worse is that, as the curves practically must all be laid down from the same direction they could turn to a tangent along the near side of the cast house wall, but could only approach it with great difficulty on the far side, a very disadvantageous condition.

A little careful consideration will show that there is no fundamental reason why the cast house should be at right angles to the stock house tracks, and when the first pair of Lorain furnaces were built an attempt was made to evade this difficulty by turning the cast houses toward one another, so making them parallel to instead of at right angles to the stock house tracks. This somewhat increased their accessibility, but took up much room, since obviously the two furnaces were more than the length of both cast houses apart.

Various modifications of the right angle plan were used, but without reaching any design which met the conditions satisfactorily. When designing the plant of the Federal Furnace Company of Chicago, Julian Kennedy adopted a plan which will undoubtedly be more and more used, though often in modified form, as time goes on. Fig. 11 shows a ground plan of these works on which the names of the different parts are clearly marked so that the arrangement is easily comprehensible. It is obvious from this plan how easily all parts of the plant are reached by railroad tracks with short and easy curves, and it will be equally obvious on a little reflection that if the cast houses had been placed at right angles to the line of the stock house trestles, in the old-fashioned way, their four sides in particular would have been almost inaccessible to railroad tracks within the yard limits available.

A further development of this idea took place when the Gary plant of the Indiana Steel Company was designed. A small scale plan of this plant reproduced from "The Iron Trade Review" is shown at Fig. 12. The scale is so small that some study is necessary to distinguish the different parts, but this can be done with a little pains.

In this case the cast houses were turned to an angle of about thirty degrees with the center line of the row of furnaces. The angle of the skip was made flatter and the base of the skip bridge further from the base of the furnace than in the Federal design so that tracks could be run along between the under side of the skip bridge and the foundation of the furnace itself, which greatly increases the accessibility of all parts of the plant to railroad tracks. These tracks underneath the skip communicate with the other tracks in front of the furnace by ladder tracks between every second pair of furnaces which run through diagonally on the same angle as that of the cast houses. These tracks serve not only the cast houses, but the dust-discharges of the different dust catchers as well. In this case each pair of furnaces becomes a lozenge shaped island in a wide river of tracks, with practically every part of the plant within easy reach of at least one track. It is seldom wise to prophesy finality in any technical matter, but the general principle of this design is so nearly perfect that it seems likely that it will eventually come to be the only plan considered for multiple furnace plants, but, of course, modifications to suit individual conditions or changes in the component parts of the plant may be made in every case.

The Distance of the Furnaces Apart

This is controlled by various circumstances. When the ore supply for the large part of a year has to be stocked that becomes one of the controlling factors because the cost of ore bridges increases very rapidly with their length, and commercially their practical length is limited on this account, as also by the great time required to traverse the trolley from one end to the other of a long bridge. The height of the ore pile is limited by considerations affecting the cost and strength of retaining walls at the sides of the stock pile, and the slope which the ore takes running back from them. The pile is thus limited in two dimensions, and in order to store a given tonnage of ore the required volume must be obtained by making the length of the

FIG. 11—GENERAL ARRANGEMENT OF FEDERAL FURNACE COMPANY'S PLANT

pile per furnace as great as is necessary, and this length is obviously the minimum distance between furnaces, for those conditions.

There are many other considerations affecting the spacing of the furnaces, however, especially in those cases where considerations of the size of the stock pile

do not control them. It is very undesirable to have the furnaces crowded together as it is more difficult to work around them under those conditions, more danger is likely to be done to one furnace by an accident at another, and questions of accessibility of various kinds arise which it is practically impossible to provide for in detail in advance, and which can only be met satisfactorily by having a certain amount of room around each furnace.

On the other hand, it is undesirable to have them spaced too far apart on account of the initial expense of land, tracks, etc., and such spacing not infrequently defeats its own ends by offering a temptation to put something into the unoccupied space, another furnace or some other part of the plant. This has happened on more than one occasion. The supervision of furnaces is also more difficult when they are scattered over too wide a territory. One blower can frequently blow two furnaces if they are spaced close together, but would not be close enough to the work to manage two located very far apart. When the stoves for each of a pair of furnaces are arranged in a continuous row as shown in Fig. 11 this in itself controls the minimum distance of the furnaces apart, as it virtually does at that plant.

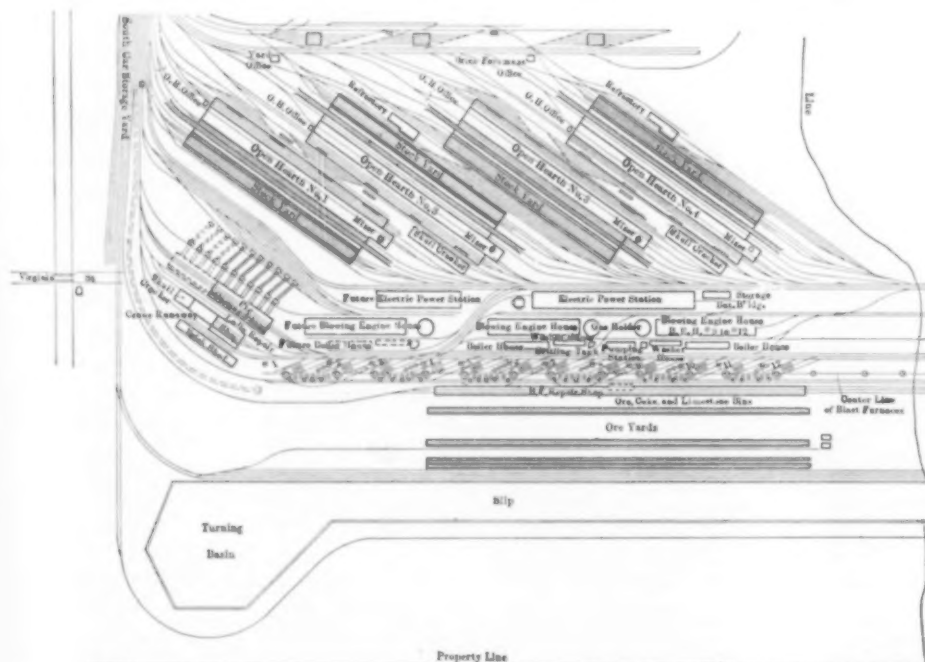Furnaces are very generally arranged in pairs, rights

FIG. 12—GENERAL GROUND PLAN AND TRACK LAYOUT FOR THE PLANT OF THE
INDIANA STEEL COMPANY AT GARY, IND.

and lefts, as shown in Fig. 11, and more clearly shown in Fig. 13, which illustrates the arrangement of a pair of furnaces with their stoves, gas mains, etc., in some detail. On the other hand, at one of the best built and most successful plants the plan was adopted of having the furnaces all built the same "hand," that is to say, looking at the plant from the front, the stoves are all on the left hand side of their respective furnaces.

One of the advantages of the pair arrangement is that it makes the distance between furnaces alternately very short and quite long. The close grouping of one pair of furnaces is an advantage since that is about the limit of what a single blower can supervise satisfactorily, and having these two close together makes it possible for him to keep in much closer touch with their operation. The fact that the next pair is several hundred feet away is of no importance to him whatever.

The Arrangement of the Stoves and Hot Blast Main

This is a subject deserving the most careful consideration. Stoves in modern practice are universally arranged in one straight row, where considerations of room permit, but this exposes the maximum amount of surface to radiation, takes up the most room, and requires the longest hot blast main.

About thirty years ago the late Samuel Thomas built the Pioneer Blast Furnaces now owned by the Republic Iron and Steel Company in Birmingham, with the four stoves at the four corners of a square, with the hot blast main running between them. This takes up much less room than the linear arrangement and shortens the length of the hot blast main by the diameter plus clearance of two stoves, and where room is a matter of importance this plan is worthy of serious consideration.

The location of the stoves in relation to the furnace is a matter of much importance from another point of view. The hot blast main becomes heated to quite a high temperature in spite of a heavy lining of fire brick, and as a result expands in ordinary cases from one to three inches. No expansion joint has as yet been designed that is satisfactory for this service on account of the high temperature to which it is necessarily more or less exposed, and in consequence one end or the other of the hot blast main must move. Owing to the construction of the hot blast valve seats shown in an earlier article these act as expansion joints to the extent of about half an inch or an inch. That is, the main can slide on the flat surface of the joint to this extent without breaking anything. The bustle pipe is suspended from the furnace itself on swinging hanger bolts, and these are free to move more or less, but movements of the bustle pipe in relation to the center of the furnace are extremely undesirable because if it was put up truly concentric with the furnace originally every change must move it from the center, which means that the distances from the base of the tuyeres to the bottom of the penstocks is not constant, as it should be, but longer on one side of the furnace than on the other. This necessitates having special blow pipes for some or all of the tuyeres and greatly increases the spares necessary to be kept on hand, and, what is even more important, increases very greatly the difficulty of changing tuyeres or the like on account of the difficulty of securing the right length of blow pipe.

For these reasons the design of the hot blast main, particularly in relation to expansion, should be very carefully considered before a final plan is adopted.

The Elevation of the Furnace

Furnaces in the early days were set practically flat on the ground and their operating level was the general ground level, it being possible to walk about them without the intervention of stairs of any kind. But the tendency has steadily been to raise the furnace proper

higher and higher above the furnace ground, primarily to permit placing ladle cars under the spouts delivering the iron and cinder from the cast house. Many low built furnaces were equipped for handling cinder in hot pots by digging deep pits for the ladle tracks and running down into these on a sharp grade. This is a way out of the difficulties which arise by not having sufficient height but it is an exceedingly poor one because it increases enormously the difficulty of pulling the cars out of the pit and of handling them in it. Moreover if a "mess" occurs, as it occasionally does in spite of the best management, the cinder and often the iron flow into the pit, or fill up the ladles, and then overflow them running down into the pit itself and making in some cases a pool two or three feet deep of molten iron and cinder at the bottom of a deep pit with masonry walls. The task of removing this, which is absolutely necessary before the furnace can be put back into operation, is bad enough to contemplate but much worse to experience, while the expense of the delay and repairs to tracks are very heavy. Even where the pig iron is handled cold, by hand, it is extremely desirable to have the cast house set well above the level of the iron shipping tracks since frequently transfer trucks are used in tak-
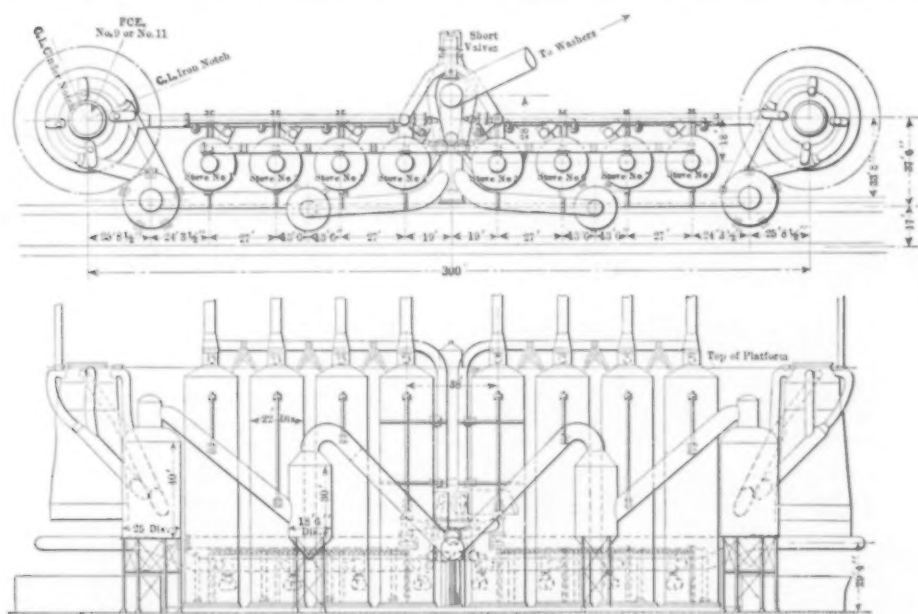

FIG. 13—GENERAL GROUND PLAN AND ELEVATION OF A PAIR OF FURNACES WITH THEIR STOVES AND DUSTCATCHER. INDIANA STEEL COMPANY, GARY, IND.

ing the iron from the cast house to the iron scales or the storage yard, or to the broad gage cars for final shipment. It is of course important to be able to drop the iron down to these transfer cars and also to drop it again to the standard gage cars. All of these considerations have demanded that furnaces be set higher and higher with the result that the hearth level at modern furnace plants is from 15 to 20 feet above the ground level.

The tracks serving the cast house and the cinder runners instead of being of the "dead end" variety as they must be if they are in pits, are, if possible, always made through tracks on the ground level, so that if there be an obstruction in one direction the liquid iron and cinder may be hauled away in the other.

It is probably advisable to go even a step further than this and to have the level of these tracks where the ladles stand on them raised a little above the level of the surrounding territory so that in case of a breakout or other accident the runaway iron and cinder instead

of forming a pool on top of the tracks to their complete destruction may run down hill off of them.

The Arrangement of the Boilers and Engines

The blast can be carried for very considerable distances from the blowing engines without much loss of pressure and with but little expense. It is therefore possible to locate the blowing engine house at a considerable distance from the furnaces, but of course it is very undesirable to carry the steam any further than is absolutely required. This means that the boiler house must be located close to the engine house, and as the gas from the furnace must be brought to the boiler house the location of the latter is deserving of considerable study.

At small plants attempts have been made to set boilers and stoves close together so that one man could attend both sets of burners, and this is on many accounts an excellent idea, but cannot generally be followed at larger plants, and therefore a location is chosen for the boiler house which will give the shortest and most convenient gas main to reach it and at the same time give the best steam connections to the engine house. It might almost be said to be standard practice to put the engine house and boiler house parallel and close to one another, although very many plants have departed from this practice for one reason or another.

Where room is an important consideration these two buildings can be placed in spaces relatively difficult of access without much detriment because very little material has to be hauled to or from them on railways, but, of course, provision must always be made to bring in an ample coal supply for the boilers even though it be useless 95 per cent of the time.

It is almost indispensable that the engine house should be served with a track to handle the heavy parts of blowing machinery during erection and subsequently during repairs, but these tracks being very little used need not have the location and alignment required for tracks carrying a continuous and heavy traffic.

The number of furnaces served by a single blowing plant must be decided by the general arrangement of the plant along the lines laid down above. The expense of carrying the blast is, as there stated, not very heavy. At the same time if it were attempted to supply blast for a large plant of eight or ten furnaces from a single blowing engine house the quantity of piping involved would become very large, and the room which these pipes would take up running, in many cases, close to one furnace in order to reach others would be a very serious matter. For this reason it is possible that four furnaces is about the limit of the number that can be advantageously blown from a single engine house. Moreover, it is to be noted that when the number of engines in the plant has reached the limit of what one given crew can supervise adequately another crew then becomes necessary, or a large portion of one, and it makes little difference in the operating cost whether these be in one house or in

two, while it makes an enormous difference both in cost and in room required if blast pipes for more than four furnaces have to be distributed from a single blower house.

The electrical, compressed air and dry blast plants are almost always located, as they should be, in or adjacent to the blowing engine house so as to be under the charge of the blowing engine operators, and served by the cranes installed over the blowing machinery. The feed pumps for the boilers were formerly in the same building but are now very generally placed in the boiler-house proper and put under the charge of the boiler house attendant. The pumping plant must be located primarily with relation to the water supply, and while it is exceedingly desirable that this also should be in the main power house it is not always possible to arrange it in that location without sacrificing even more important considerations. At the same time the cost of attendance of isolated plants of relatively small power is very high as compared to that in a single large power house, and for this reason the pumping plant should be either in the main power house or as close to it as practicable.

Arrangements for the Disposal of the Iron

These necessarily vary according to the purpose of the plant. If it be a component part of a steel works then the prime consideration is safe and convenient methods of hauling the ladle cars to and from the steel works. If on the other hand the furnaces constitute a merchant plant all the iron is required to be cast either in beds or a pig machine. In the latter case the location of the pig machine is a matter of some moment as is also the location of its service tracks. In an earlier article were given a description and illustrations of a pig machine plant with an excellent arrangement of "ladder" tracks. Such an installation can within reason be located wherever consideration of tracks and space require.

The Disposal of the Slag

The prime consideration in this is that the runners shall be short since even the hottest and best-running cinder builds in the bottom of the trough and has to be cleaned out and disposed of before the next flush. The labor required for this increases almost as the square of the length of the trough and it is therefore very important to keep the latter as short as possible whether it is to discharge into a hot pot or into a granulating pit.

The location of the slag dump for the final disposal of the slag may be any distance up to one or two miles or even twice as much, but of course it is desirable to keep this distance as small as possible in order to diminish the time of the ladle cars on the road and so enable the smallest number of them to perform the necessary service.

Panama Canal Commission Award.—The contract for furnishing material under circular No. 891 for complete pumping plant for Dry Dock No. 1, Balboa Terminals, Balboa, Canal Zone, Isthmus of Panama, was awarded by the Panama Commission to Henry R. Worthington, N. Y. The contract involves design, fabrication and delivery on the Isthmus of the structural, mechanical, electrical and hydraulic parts required for this installation. The pumping plant comprises four 1000-hp. main pumps, two 200-hp. drainage pumps and one bilge pump. The contract further includes all of the hand and power operated gate valves as well as the automatic check valves. For operating the gate and sluice valves by power a hydraulic pressure system is provided consisting of a weighted accumulator and the necessary pressure pumps in duplicate. Delivery is guaranteed within 210 days.

Faraday Society Meeting

The seventy-fifth ordinary meeting of the Faraday Society was held on May 11, 1915, at the Institution of Electrical Engineers in London. The president, Sir Robert Hadfield, was in the chair.

Prof. ALFRED W. PORTER read a paper "On Von Babo's Law and Kirchhoff's Equation for the **Latent Heat of Dilution.**"

The following are the chief points in the paper:

1. Accurate formulas are found for the heats of dilution (both reversible and irreversible) for a solution of any concentration at any hydrostatic pressure.

2. A sufficiently accurate formula is obtained connecting the heat of dilution with vapor pressures. Von Babo's law is discussed in this connection.

3. It is shown that, at any rate for sugar solutions

$$\log \frac{\pi}{\pi_0} = \frac{n}{N - an} \text{approximately,}$$

where a is the hydration factor of the solute.

4. It is emphasized that $N - an$ cannot be interpreted as the number of effective molecules of solvent in the solution on account of the association of the solvent molecules with one another. For example, in the case of water the association is almost certainly between 2 and 3. Hence the actual number of solvent molecules *in the solution* which are unattached to solute is between $\frac{N}{2} - an$ and $\frac{N}{3} - an;$ because N is the number of molecules of solvent reckoned as in the vapor state, and steam is not associated.

Mr. D. ORSON WOOD read a paper on "The Vapor Pressure of Concentrated Sugar Solutions."

The vapor pressure of solutions containing approximately 50, 60 and 70 grams of cane sugar per 100 grams of solution have been determined by a static method for the temperature range 60 deg. to 90 deg. C. The results show that the lowering of the vapor pressure of the solution relative to that of water (Babo's constant) decreases slowly with temperature, and the variation indicates that heat should be evolved when the solutions are diluted with water, thus agreeing with the previous work on the latent heat of dilution.

The value of Callendar's hydration factor a is calculated for each solution. It varies continually with temperature from 3.5 to 4.5; but the mean in each case is very nearly 4, not 5, the value given by Callendar for less concentrated sugar solutions.

The osmotic pressure is deduced from the vapor pressures by means of Porter's equation. For the strongest solution it is of the order of 320 atmospheres. It has a tendency to decrease with rise of temperature. The theoretical aspects of all these results are considered at length.

A paper by Mr. F. J. HARLOW and Mr. R. S. WILLOWS on "A Simple Method of Deriving the Gibbs Adsorption Formula" was read by Mr. Harlow.

The usual method of deriving the Gibbs adsorption formula involves the use of chemical potential. As students find a difficulty in understanding this, a simple method of obtaining the formula is given which involves only elementary thermodynamics.

Mr. F. H. CAMPBELL communicated a paper entitled "The Vapor Pressures and Specific Volumes of Binary Mixtures of Volatile with Non-volatile Liquids."

By the use of a new method, the effect of varying quantities of a liquid of negligible volatility upon the vapor pressure of volatile liquids dissolved in them has been determined.

It has been shown that the results receive adequate qualitative explanation, on the assumption that the form of vapor pressure curves is determined by molecular

changes accompanying the process of solution. Thus the solution may consist of a smaller number of particles than did the liquids constituting it before admixture, as the result of solvate formation; the number may be greater, owing to dissociation of an associated liquid. Probably the commonest case is that in which both solvate formation and dissociation occur together.

Attempts to apply Dolazalek's theory quantitatively were not successful, even in the simplest cases. It must be concluded that it requires amplification.

An explanation of the apparently abnormal behavior of certain mixtures is put forward.

The specific volumes of a number of mixtures of pairs of liquid have been determined.

Mr. R. H. CALLOW communicated a paper on "Reaction Velocity in Viscous Media."

The reaction considered was the hydrolysis of methyl acetate in gelatine-water mixtures by NaOH and HCl. Conductivity experiments on the alkaline hydrolysis failed to give satisfactory results owing to the hydrolysis of the Na salt of gelatine. The acid hydrolysis gave a series of velocity constants which showed a diminution as the gelatine concentration increased. The change in the velocity constant was small compared with the change in the viscosity, e. g. the velocity constant for the reaction proceeding in a set jelly was only about 10 per cent less than that in the case where no gelatine was present. The curves showing the relation between the velocity constant and the viscosity and fluidity of the mixtures do not appear to obey any simple relation. The fall in the velocity constant is supposed to be due partly to the neutralization of the HCl by the gelatine, and partly to the viscosity. The author suggests that the effect of the viscosity is given either by a reciprocal relation such as $\eta(K - c) = $ const., where c is a constant, or by an exponential function.

Mr. K. C. BROWNING and Mr. C. T. SYMONS sent in a description of "A Convenient Thermostat for Accurate Specific Gravity Determinations and a Gas Pressure Regulator."

The authors, having had occasion to make a number of accurate specific gravity determinations, devised a thermostat the temperature of which can be kept constant to considerably less than 1/100 deg. C., which has advantages over others they are aware of.

The advantages of this regulator are:

1. It does not leak either at the valve or at the flexible top. If a gas pressure of 30 in. water be applied at the inlet, a water gauge at the exit will not alter its level perceptibly when the pressure at the inlet is maintained for half an hour.

2. It is portable and takes up little room.

3. It can be rapidly set for any desired reduction of pressure.

4. It does not require careful leveling and is very strong.

Mr. E. J. HARTUNG communicated a paper on "A New Method for Determining the Specific Heats of Liquids."

In the course of a research on certain thermal properties of binary liquid mixtures it was found necessary to measure the specific heats of a large number of liquids. It was therefore very desirable to have a simple, rapid and reasonably accurate method of measurement. The paper contains an account of a method which has been found very suitable for the purpose named. It has the added advantage of requiring a relatively small quantity (60 c.c.) of the particular liquid for a determination. The method retains the simplicity of the old mixture method for measuring specific heats while greatly diminishing its serious errors.

The initial idea, from which the method was worked out, was supplied by Prof. Orme Masson, who suggested that the liquid in question be cooled by the application of a known weight of dry ice sealed up with a roll of silver gauze in a thin glass bulb. This suggestion was acted upon, and, after suitable apparatus had been constructed, good and consistent results were obtained. The method in brief consists in freezing the bulb containing the water in a suitable apparatus and then introducing the bulb into the liquid in the calorimeter and noting the fall in temperature.

Mr. J. S. ANDERSON contributed a paper on "An Electromagnetic Vacuum Balance."

The balance was designed to allow weighings being carried out *in vacuo*. The principle involved is that of the well-known Kelvin balance for "weighing" electrical currents. One of the scale-pans of an ordinary balance is replaced by a circular coil of wire which is movable between two larger fixed coils of wire, the three coils having a common vertical axis. The coils are so connected that, when a current of electricity is passed through them in series, the movable coil is attracted by the lower, and repelled by the upper, fixed coil. These attractive and repulsive forces, which may be increased or decreased by varying the electrical current, are made use of to counterbalance the action of gravity on the substance to be weighed in the scale-pan hanging from the other end of the balance-beam. Should the weight of the substance vary from time to time, the variations in weight can be determined by altering the current through the coils until equality of the forces acting on the two ends of the balance-beam is obtained. The balance must first, of course, be calibrated.

The base of the balance is fixed to a glass plate, over which a bell-jar is placed, thus allowing of the apparatus being evacuated. Two terminals, which serve for leading in the current for the coils, pass through the glass plate. The arrestment is controlled by an electromagnetic device operated from outside the balance. Attached to a lever at the back of the balance are two iron rods which can move freely in a vertical direction inside two solenoids. When an electrical current is passed through one solenoid the balance beam is released; when passed through the other solenoid, the beam is fixed. As soon as the beam is either released or fixed, the current may be switched off without altering the position of the beam.

A difference in weight of .35 to .7 milligram could easily be detected when use was made of an amperemeter which was not very sensitive. The balance is specially suited for measuring changes in the weights of substances *in vacuo*. Measurements were made of the velocity of absorption of water vapor by silicic acid gels.

Mr. E. B. R. PRIDEAUX sent in a "Note on the Neutralization Curve of Boric Acid."

The hydrion concentrations of boric acid at various degrees of neutralization may be calculated with one dissociation constant. If that of Walker $K = 1.7 \times 10^{-9}$ is used, the calculated acidities over the greater part of the curve are too high as compared with the experimental values of Sorensen. A modified dissociation constant $K = 4.5 \times 10^{-10}$ derived from these values gives a good agreement, except that the acidity is too low at the acid end.

These differences are accounted for by the formation of complexes in solution.

Mr. NORMAN MURRAY BELL contributed a paper "On the Anodic Solution of Lead."

This paper is due to an attempt made to collect further evidence bearing on the production of monovalent lead ions (Pb.), the existence of which in aqueous solution has been inferred by Denham (*F.C.S.*, 93, 424, 833).

The results of the preliminary investigation of the

electric solution of an anode of pure lead in six different electrolytes, viz. lead acetate, potassium hydrogen tartrate, hydrofluorsilicic acid, sodium acetate, potassium bromide, and sodium thiosulphate, are here recorded. Of these the sodium acetate and the sodium thiosulphate yield apparently positive evidence. The author hopes to be able soon to supply a more detailed study of these two solutions.

Mr. F. C. THOMPSON communicated a paper on "The Elastic Strength of Metals."

In a normal pure metal the inter-crystalline boundaries are by far the strongest part of the whole. This rather unexpected fact has recently been explained by assuming that a hard vitreous modification of the metal exists between the crystal grains, the strength of which "cement" is sufficiently great to stiffen up the whole mass. This explanation, however, necessitates the assumption of a tensile strength for the cement of an almost impossible order.

On the assumption that surface tension effects are to be expected in the "glassy" films, an expression for the elastic limit of a pure metal is derived.

If E is the E.L. in dynes per sq. cm.,

n is the number of crystals per cm.,

T is the surface tension of the films, and

d is their thickness,

$$E = 1.5n \frac{T}{d}$$

(1)

The equation agrees well with recent work on the yield-point in metals and on their mechanical properties at high temperatures.

Bars of pure lead, tin, zinc, antimony, silver, copper, iron and nickel were used to test the relationship, the iron being used in five different conditions.

Although this equation governs the elastic limits of metals, the maximum stress and Brinell hardness are dependent on other terms, chiefly the "intrinsic pressure," with the result that alterations may be made in the elastic limit of a material without appreciable effect on its hardness.

The electrical resistance of a normal metal ϱ is shown by measurement of the samples of treated iron to be the sum of the resistance of the crystalline material ϱ_1 and an added resistance due to the crystalline junctions, so that if n is the number of the latter per centimeter and R their resistance,

$$\varrho = \varrho_1 + nR$$

(2)

Thus from (1) and (2)

$$d = \frac{1.5T}{E} \cdot \frac{\varrho - \varrho_1}{R}$$

(3)

which allows d, the thickness of the film of undercooled metal between the crystals, to be calculated.

Results are obtained for a pure iron, and discussed in their bearing on the theories of the origin of the films.

Mr. LESLIE AITCHISON sent in a paper entitled "Experiments on the Influence of Composition upon the Corrosion of Steel."

The work embodied in this paper has been performed upon a series of some sixty steels, comprising (1) plain carbon steels, (2) steels containing a constant proportion of carbon and varying proportions of tungsten, chromium, cobalt or vanadium, (3) steels with constant proportions of tungsten, chromium, vanadium, manganese or nickel, and (4) some steels containing copper. The attacks recorded are those of (1) 3 per cent sodium chloride, (2) 10 per cent sulphuric acid, and (3) 1 per cent sulphuric acid. The work shows that in the case of the pure carbon steels an increase of the corrosion produced at first a fall of the corrosion and then a rise to a well-marked maximum of 0.9 per cent of carbon. The addition of varying proportions of tungsten to a

series of steels containing about 0.7 per cent of carbon has produced a definite increase of the corrosion throughout. Varying percentages of cobalt added to a similar series have produced an increase of the corrosion with the presence of smaller quantities of cobalt, and in all cases a gradual fall of corrosion with a rise of cobalt. In the two acid solutions the higher proportions have produced a corrodibility less than that for the corresponding pure carbon steel. The presence of vanadium in varying proportions has resulted in a definite increase of the corrodibility. The addition of chromium produces an increase of the corrosion up to 5 per cent, then a remarkable fall to a material containing 19 per cent of chromium, which is quite non-corrodible in brine, and almost so in 1 per cent sulphuric acid, but which is highly corrodible in 10 per cent acid.

In the third series the percentages of the third elements present are fairly low, and the addition in all five cases has produced an increased corrosion in brine. In the 1 per cent acid, tungsten and nickel have (in general) produced a decrease, while vanadium and manganese show a tendency to produce an increase of the corrosion. In the 10 per cent acid, tungsten and nickel generally produce a decrease, while chromium, manganese and vanadium show a distinct increase. The steels containing copper show an increased corrosion in brine and 1 per cent acid, but a decreased corrosion in 10 per cent acid, after the copper has risen above 1 per cent.

In general it is suggested fairly strongly that anything tending to the production of finer pearlite in steels, but which does not produce a mixture of carbide and solid solution (as distinct from a eutectic), causes an increase in the corrosion of the material. The relation of the presence of carbides to the corrosion is also discussed. Further conclusions to be drawn from the work are postponed until other experiments on the question have been published, these being promised for the near future.

The discussion on this paper was postponed until the autumn, when a general discussion will be held on "The Corrosion of Metals—Ferrous and Non-ferrous."

Oxy-Hydrogen Electrolytic Cells for Japan.—The Tokio-Electric Co. has ordered a large installation of I. O. C. cells for the electrolytic production of oxygen and hydrogen gas from the International Oxygen Co., of New York.

Electric Steel Furnaces.—The Halcomb Steel Co., of Syracuse, N. Y., who installed the first electric steel furnace in America seven years ago, have contracted for a three-ton Snyder electric furnace, which will run basic, melting and refining cold material. It will have a 24-hour output of 24 tons of refined steel and will melt cold scraps and refine it on a basic bottom. Messrs. S. Fair & Son, Inc., of Saginaw, Mich., have contracted with the Snyder Electric Furnace Co. of Chicago, for the installation of a furnace with a 24-hour output of 8 tons of refined steel. It will receive cold charges and will be used for making high-grade vanadium steel castings.

Antimony.—Construction on the first antimony smelting plant on the Pacific Coast was begun at Harbor Industrial City, Cal., on April 8. It is reported that the capacity of the plant now under construction and which is to cost $75,000 will be 1000 tons per month. It is to be built with a view to future extension to much larger capacity. The smelter is being erected by the Merchants' Finance Company represented by M. Elasasser and Henry E. Simpson on part of a 6-acre tract purchased for the purpose.

Metallurgical and Chemical Engineering in Great Britain

(From Our London Correspondent)

Technical and Scientific Attaches

In Elizabethan days a cynical diplomat described an ambassador as a good man sent to lie abroad for the sake of his country. I cannot remember a good epigram concerning naval and military attaches, nor can I perpetrate an indifferent one as to the new class of diplomatic officials suggested in a short paper appearing in the Journal of the Institution of Electrical Engineers. This short monograph pays a high tribute to many German qualities unrecognized in the days before the war: "Much, very much more than is supposed, of German success in the past has been due to the possession of scientific and commercial imagination. Others, time and again, have done the pioneer work, have opened new fields of discovery, but it has been left to the imaginative Teuton to carry the discovery to its logical conclusion, to foresee its fields of application, and to build thereon great and remunerative industries. We shall be indeed a short-sighted race if, when military warfare gives place to the commercial warfare waged by manufacturing countries for foodstuffs and luxuries, we do not strain every nerve to apply systems to our methods. We must remember that the added burdens not only of direct taxation but of reduced numbers of food-getters will render commercial success more vital to our welfare than in the past. Europe has had one example of an economic rehabilitation and industrial renaissance of a conquered nation following upon defeat and the payment of a big war indemnity. It is well within the bounds of feasibility that German industrialism may make a recovery not quite so rapid, but sufficiently rapid to justify forethought at this stage. At the time of writing, her factories and equipment are uninjured. Only raw materials and markets are needed for industrial production to be resumed. The raw material can be produced or obtained; there will be every incentive to regain the latter. Just as the important and in some respects almost dominating position which Germany held in the neutral markets of the world before the war was in part due to the thorough and systematic methods of her commercial engineering departments, so her innate gains of organization and co-ordination, her capability of concentration of purpose, and her logical industrial imagination, will guide and steady her progress toward a recovery of her previous position. To this she will be relentlessly spurred by the grimmest of necessities, that of food earning."

The remedy or weapon advocated by the author of the monograph is that of a new type of attaché at our legations and embassies. "Unless written by specialists, neither the reports of commercial attachés and trade commissioners nor the consular reports can be reasonably expected to give details, say, of the successful types of competing foreign manufactures, the reason of lower price, the reasons apart from price why British types are not successful, and the local conditions which may render British articles unsuitable.

"The professional status of a technical commissioner, say, in engineering, should be at least the equivalent of full membership of one or more of the institutions most closely concerned in his work, viz., the respective institutions of mechanical engineers and of electrical engineers. Those concerned with mining machinery or metallurgical matters should belong among other bodies to the Institution of Mining and Metallurgy. The chemist, too, should possess equivalent qualifications. Were it once decided to appoint technical commissioners, the councils of the various institutions could submit names to the Secretary of State, who would make a selection therefrom in the usual manner. Before proceeding to take up his post, the newly appointed technical commissioner should have ample opportunity of conference with representatives of the industries concerned with his sphere of work, both as regards their selling and their technical departments, and methods of manufacture. At stated intervals he should return to England to confer with those concerned in his work."

The author has, however, omitted to say that certain reports issued by your Bureau of Standards in Washington would prove useful models, and are convincing examples of what can be done. Also, too, but not so well known, are the published Japanese reports. The unpublished Japanese reports, moreover, would probably surprise many people, not only in Europe but on your side also.

Government Aid for Scientific Research

The Rt. Hon. J. A. Pease, who until the reconstruction of the Cabinet was President of the Board of Education, has made a very important announcement in the House of Commons. In the course of his annual statement he observed that the war had shown up the fact that Great Britain was far too much dependent on the foreigner for many processes and for much material. It had made us realize that if we were to maintain our manufacturing position in the world we must endeavor to promote a better system for the encouragement of scientific research, especially in the universities. He stated that he could give case after case where, by research and by a little expenditure in connection with the training of scientific and able men, we would be able as a country to succeed just as Germany had succeeded. His fear was that after the war we should have to contend with a fiercer competition than that which we had had to contend with in recent years. The government agreed with him that something ought to be done at once, that we must make more use of the workers who exist in our country and prepare for an increased supply of them, that we must bring our universities and technical schools into closer association with industries and bring our leaders of industry into closer association with skilled workers. He proposed to proceed at once to the appointment of an advisory council in industrial research. He wanted a committee of experts who themselves would be able to consult with other expert committees working in different directions. They in turn must be associated with leaders of industry. The department would work in close co-operation with the Board of Trade. He hoped the Advisory Council would be at work within the next few weeks. He hoped to place on the supplementary estimates a vote of between £25,000 and £30,000 as a beginning. The schemes must be dependent on state help for years to come, and this state help must steadily progress.

The Iron and Steel Institute

THE SECOND DAY'S MEETING

The second day's meeting was much quieter than the first. A resolution drafted by the Council removing the names of all alien enemies from the list of members was considered and adopted. After this the Carnegie Medal, which had been awarded to Mr. E. Nusbaumer of Paris for his researches on "Rotary Bend Tests," was handed to Mr. H. Le Chatelier, as Mr. Nusbaumer was serving with an artillery regiment.

The first paper discussed was that by Dr. A. McWilliam and Mr. E. J. Barnes on the "Brinell Hardness and Tenacity Factors of a Series of Heat-Treated Special Steels."

Dr. C. A. Edwards, who opened the discussion, said that in certain experiments which he had carried out with chrome steels he had found that when heat-treating them in various ways he obtained different variations in the Brinell hardness; this he illustrated by a number of curves on the blackboard. He had concluded from the tests he illustrated that chrome steel was a self-hardening steel. When tungsten was also present the effect was not due to the tungsten, but was due to the chromium. He (the speaker) had taken curves of a 6 per cent chrome steel, and had found that in cooling down great variation occurred in the occurrence of the critical points, and his experiments pointed out that by carrying out cooling at different rates in a laboratory it was possible to control any property of the steel.

Mr. H. Le Chatelier, who followed, said the experiments carried out by Messrs McWilliam and Barnes confirmed the absence of proportionality between the Brinell hardness number and the yield point. For the passing of certain material in the case of which the yield point was of the greatest importance, the use alone of the Brinell test would not afford a sufficiently accurate guide. On the other hand, the Brinell test could be resorted to, and serve as a guide when other conditions are extant for determining the metal; when, for example, the chemical composition or thermal treatment was known. The constancy in these conditions, coupled with the fixity in the hardness number, sufficed to show that the characteristics of metals which were being compared together remain constant, the yield point, therefore, remaining also constant.

Dr. Stead found the paper most interesting, in that it pointed out the value of the Brinell testing machine. This machine was now in almost constant use, and it should be met with in every works, since in one minute it was able to give a good indication of the properties of the steel.

Dr. Rosenhain said it would be wrong for the Brinell test to be resorted to for investigating new material, but it was a useful method for a number of purposes, such as routine tests carried out when comparing series of similar pieces similarly treated. He indorsed Mr. Le Chatelier's remarks.

Dr. J. E. Stead then read an abstract of his paper on "Iron, Carbon and Phosphorus." Much of the discussion was devoted to methods of detecting phosphorus—the beautiful photo-micrographs in color which accompanied the paper were greatly admired, and favorite etching media warmly praised or sharply criticized according to the predilections of the speakers. For instance, Dr. W. H. Hatfield was not really satisfied with either Dr. Stead's or Dr. Rosenhain's reagents. Mr. H. Le Chatelier said that a very simple means for characterizing phosphide of iron was to have recourse to caustic soda and electric current. The phosphide of iron was attacked and the cementite remained intact. He added that electrolytic methods could, he thought, be used more frequently than they were at the present time; they made it easily possible to regulate the action of the reagent.

Dr. Rosenhain said that the reagents were new in the sense that they had been worked out a little more fully than formerly. Osmond used copper solutions for etchings, but he (the speaker) believed Osmond removed the copper from the surface. There were two kinds of actions, a dissolving one and a pure etching one, with at the same time a deposition of copper. One or the other might preponderate. If the etching action preponderated the effect would be similar to that with picric acid. Ghost lines were so common in all commercial steel that it was ridiculous to say that the mere existence of bands containing more or less phosphorus

necessarily rendered the steel bad. But when the bands were excessive in number or in width and intensity, it was necessary to beware of them. There was a concentration of phosphorus in the bands. There occurred also alternate layers of two materials which differed in their critical temperatures and in their mechanical properties, both hot and cold. They were being rolled or forged together, and they were unequally expanded in the process. Their internal behavior was different, with the result that internal stress was produced when the metal cooled. Where large plates had cracked spontaneously, the cracking was associated with a large amount of banding and with a large difference in the phosphorus content between successive layers. There was also the effect of the bands upon the critical points of the steel. He (the speaker) thought Dr. Stead had got over the difficulty with his reagent. To judge properly of the new copper solutions extremely low magnifications had to be used, 2, 3 or 4 diameters at most. He (the speaker) thought Dr. Stead was right when he said that the whole question of the rate of deposition of copper was the ease of sollubility of the ferrite, and consequently the question of the purity of the ferrite. Carbon dendrons were not obtained when the metal was etched with picric acid, because the carbon diffused so rapidly. Silicon diffused more rapidly than phosphorus. Phosphorus, in fact, was one of the most slow diffusing components, if not the slowest.

Other speakers included Mr. E. H. Saniter, Mr. R. G. Scott, Dr. McWilliam and Dr. Edwards. Dr. Stead in his reply agreed with what Dr. Hatfield had said, as his own experience was practically identical. But the reagents were not intended to apply to pig iron, to which Dr. Hatfield had applied them. With pig iron Dr. Stead had also found they not only showed the phosphorus areas, but also silicon concentrations, which had never been shown in pig iron by any other reagent. Up to 5 per cent silicon there occurred a large area which remained white. The graphite had decomposed into pure iron and graphite, while the silicon in the primary crystalite form had not had time to diffuse out. Dr. Hatfield's magnification was too great. Mr. Le Chatelier's method was a good one for detecting free phosphorus, but it did not apply to phosphide in solid solution. He agreed with Dr. Rosenhain on all points. Other things besides phosphorus interfered, and it was necessary to be careful in the use of reagents.

The last paper read and discussed was that by Mr. Kotaro Honda of Tohoku University, Japan, and dealt with "The Nature of the A_2 Transformation in Iron." The speakers were Dr. Stead, Mr. H. Le Chatelier and Dr. Rosenhain.

Market Prices

JUNE, 1915

Tin opened at £162, fell to £160 (3d), and then rose steadily to £167 (9th). After a slight drop to £166.10 (10th) it rose sharply to £175 (14th), then fell to £168.10 (17th), recovered to £171 (19th), again dropped to £168.10 (25th), after which it improved considerably, closing at £172.10.

Haematite has remained steady at 95/- throughout the month.

Scotch Pig opened at 71/6, and remained steady till the 8th, it then rose slowly to 74/- (15th), declined to 72/- (20th), recovered to 72/6 (22d), and after slowly falling to 72/- (29th) it rose slightly, closing at 72/6.

Cleveland opened at 65/6 and remained steady till the 8th, it then improved to 67/6 (15th), declined to 66/- (20th), recovered to 67/- (22d), and after slowly falling to 66/- (29th) it rose slightly and closed at 67/-.

English Lead opened at £21.10 and rose steadily to £28.10 (15th), it then dropped rapidly to £26.10 (16th), and after a slight improvement to £27 (18th) declined to £24.10 (24th). It then rose decidedly, closing at £27.

Copper opened at £79.10, improving to £83.5 (6th), and after a slight fall to £83.15 (8th) continued to rise to £86.10 (14th). It then fell sharply to £82 (18th), recovered to £83 (20th), but went lower to £81 (24th), and after improving to £82.10 (25th) it declined slightly, closing at £82.

	£	s.	d.
Aluminium, ton lots	105	0	0
Antimony, black sulphide powder, ton	70	0	0
Borax, ton	22	0	0
Copper sulphate, ton	29	0	0
Caustic soda, 70 per cent ton	10	2	6
Ebonite rod, lb.		3	0
Hydrochloric acid, cwt		4	6
India rubber, Para, fine, lb.		2	7½
Mica, in original cases, medium	3/—to	5	0
Petroleum, water white, gal.			9¾
Quicksilver, Spanish, bottle	16	10	0
Sal-ammoniac, cwt.	2	9	0
Shellac, cwt.	3	5	0
Platinum, oz. nominal	9	5	0

Recent Chemical and Metallurgical Patents

Iron and Steel

Combustion Apparatus for Carbon Analysis.—A form of apparatus for making carbon determinations has been patented by Mr. JOHN S. COX of Buffalo, N. Y. It is an improvement on the type in which a water-cooled stopper fits a crucible in which the combustion takes place. The idea is illustrated in Fig. 1, in which *A* represents the crucible and *B* the cover, the latter having the usual tubes *bb'* for ingress and egress of oxygen and other gases. The crucible has a flange *c* which fits into an annular depression *e'* in the annular cooling chamber *E*. The crucible cover *B* also has a flange *c'* corresponding with the flange on the crucible and between these two is placed a gasket of rubber, *D*. The cooling chamber has suitable inlet and outlet tubes *f* and *f'*, the latter not shown, for the circulation of cooling water. A screw *G* is provided to secure the cover firmly in place on the crucible and form a tight joint. Advantage is claimed over similar apparatus in which a cooling chamber is

FIG. 1—COMBUSTION APPARATUS

formed integrally with the crucible, because the cooling water forms incrustations in the chamber. An improvement is claimed also over apparatus with a water-cooled stopper, because the latter tends to condense atmospheric moisture on its surface that is likely to run into the crucible when the stopper is removed. (1,140,802, May 25, 1915.)
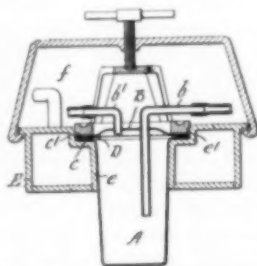
Aluminium

Aluminium Nitride.—Some interesting developments in connection with aluminium nitride manufacture in the electric furnace, are brought out in patents recently issued to Mr. PAUL BUNET of Whitney, N. C., and assigned by him to the Société Generale des Nitrures, of Paris, France, which company owns the Serpek patent. Special interest attaches to these developments in view of the fact that a large plant has been in course of construction at Whitney, N. C., for the manufacture of aluminium. Detailed information on the Serpek process may be found in METALLURGICAL AND CHEMICAL ENGINEERING, Vol. XI, pages 137 and 139.

The raw materials are essentially the same in this new process as in the Serpek process, but the new process embodies a departure in the fact that the mixture of alumina or aluminous material and carbon is used itself as the heating resistor. The mixture advances in the furnaces in the same general way as in the Serpek process, but owing to the fact that carbon is used up in the reaction it is necessary to adopt some means of keeping the current normal. This is effected in two ways: either by increasing the thickness of the layer of mixture as it advances and becomes poorer in carbon; or by interposing electrodes into the mixture at intervals which can be adjusted according to the conductivity of the mixture between them.

Two types of electric furnace in which the above process may be carried out are also patented by Mr.
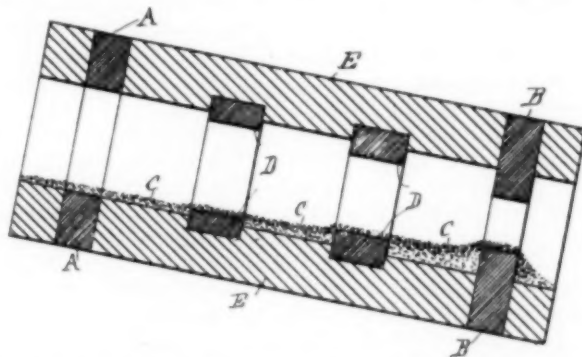

FIG. 2—ELECTRIC FURNACE FOR ALUMINIUM NITRIDE

Bunet. The first is a furnace in which the thickness of the layer of mixture increases with the advance, and the second effects the uniform passage of the current by having electrodes interposed in such a way that the distance between them can be regulated according to the conductivity of that part of the mixture. These two types may be combined. A drawing of an inclined revolving furnace of the first type is given in Fig. 2, in which *A* and *B* are annular conductors, the lower electrode *B* projecting into the furnace so as to form a diaphragm to retain the mixture *C* traveling through the furnace. *DD* are conductive rings which may be placed in the refractory lining *E*, thus allowing of a better passage of the current. These rings may be projecting on not. (1,145,747 and 1,145,-748, July 6, 1915).

Aluminum Alloy.—An alloy consisting of aluminum, silver, copper, and cadmium, which is very useful for casting purposes, is patented by Mr. WILLIAM A. MC-ADAMS of Bay Shore, New York. This alloy is not corroded by the action of the ordinary city water and has withstood pressures up to two hundred pounds per square inch without sweating. (1,146,185, July 13, 1915).

Zinc

Treating Zinc-Bearing Materials.—Improvements in electrical zinc smelting are the basis of a patent of Mr. WOOLSEY McA. JOHNSON of Hartford, Conn., and assigned to the Continuous Zinc Furnace Company of Hartford, Conn. A process is described for treating zinc-bearing slags, by reducing the zinc from the slags with iron, the zinc being subsequently volatilized and condensed. The slags treated are such as come from the lead blast furnace or from the reducton of ores containing zinc and copper. "Such slags are essentially silicate compositions in which iron and calcium predominate, carrying minor proportions of aluminium, manganese and magnesium, and containing some 8 per cent, more or less, of zinc oxide."

A cross section of the author's furnace is given in

Fig. 3, in which 1 represents the refractory structure, in a metal sheath 2. Interior chambers 3 and 4 are separated by partition 5, which is cooled by water pipes 6. A layer of molten iron on the hearth is indicated by 7 and 8,8 are the lower electrodes. Above the molten iron is a layer 9 of molten zinc-bearing slag, 10 being a runway for introducing same. The upper electrodes 11,11 depend into the slag. 12 is a flue for the volatilized zinc, 13 represents a tapping hole for slag, 14 a tap for matte, and 15 a lead tap communicating with a sump 16; 18,18 are hoppers for introducing coal or coke; 19 and 21,21 are tuyeres.

In operation of this particular type of furnace, the iron is run into the furnace in the molten state and in quantity sufficient to cover the hearth to a depth of a few inches. Fluid zinc-bearing slag is run in above the iron, and the temperature maintained at a point sufficient to effect the reduction of the zinc by the electric current.

This reduction occurs in accordance with the following reaction:

$$Zn\,O\,SiO_2 + Fe = Zn + FeO\,SiO_2.$$

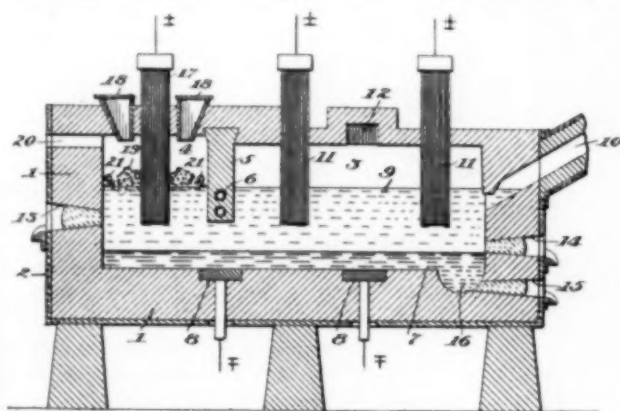The zinc vapor passes from the furnace by flue 12. The slag, denuded of most or all of its zinc, and pro-

FIG. 3—ELECTRIC ZINC FURNACE

portionately enriched in iron, flows beneath the depending wall 5, into the furnace chamber 4, in which it is smelted in the presence of carbon. In this operation a certain portion of the iron is reduced to metal, and collects in the layer 7, serving to replenish same. The slag level may be maintained by tap 13 and lead carrying any gold and silver drawn out through tap 15. Instead of slag derived from lead blast furnaces or the like, the process may, of course, be operated with a properly compounded ore-charge from any source. In conjunction with a lead blast furnace the slag would be run into the electric furnace, thus conserving the heat, and "the lead blast furnace may be operated at high capacity and without strict regard for exact metallurgical conditions, the rich slags thereby formed being readily worked in accordance with the present process." (1,146,-075, July 13, 1915.)

Roasting of Zinc Ores.—An improvement in roasting furnaces for zinc ores is patented by Mr. JOHN J. SIMMONDS of Iola, Kan., relating to that type of roaster in which two tiers of hearths are disposed side by side, and through which rabbles are drawn and transferred from the hearths in one tier to those in the other. The mechanism operating the rabbles is in connection with an engine or motor running continuously in one direction, and which does not have to be reversed in order to reciprocate the rabbles. The means for controlling the reversing mechanism, and for throwing the rabble-operating mechanism into and out of connection with the driving engine, are controlled from an opera-

tor's platform adjacent to the furnace. (1,133,068, March 23, 1915.)

Gold and Silver

Chlorination of Ores.—The production of electrolytic chlorine from salt for use in chlorinating the metals in gold, silver and copper ores, is the basis of a patent granted to Mr. JASPER A. McCASKELL of Salt Lake City, Utah. An aqueous solution of the chlorides of the metals is subsequently electrolyzed in the cathode side of a diaphragmed cell, resulting in the regeneration of the original chloride solution and the deposition of the metals. The process and apparatus are illustrated in Fig. 4, in which A represents an agitating tank in which the ground ore pulp is treated with chlorine delivered from the tank F in which the gas has been stored under pressure. The chlorine gas itself is thus used as the
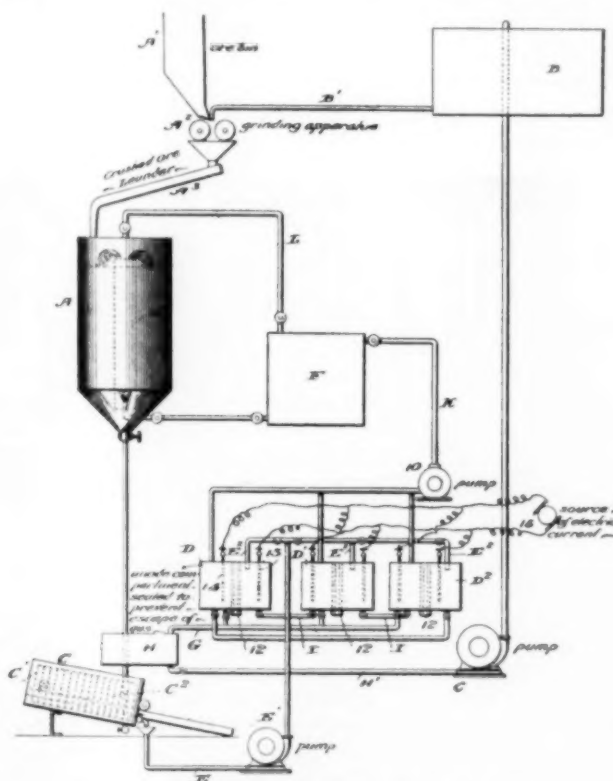

FIG. 4—PROCESS OF CHLORINATING ORES

agitating medium. If the ore contains silver, sodium chloride is added to the water used in crushing, being delivered from the tank B. After the first cycle the tank B will contain spent liquor from the anode compartment of the electrolytic cells. After the ore is chlorinated in tank A it is filter-pressed, and the liquor is delivered to the cathode compartment of the cells. The diaphragm is impervious and serves as a bi-polar electrode. It is formed of two sheets of asbestos or two pieces of porous earthenware between which is a thin film of mercury. The solution of metallic chlorides being under electrolysis, the metals collect at the cathode and the chlorine tends to accumulate at the diaphragm. In the anode compartment the sodium chloride is dissociated, the chlorine collecting at the anode and being used as already described, while the sodium collects at the diaphragm and amalgamates with the mercury. Ultimately reaction will occur between the sodium and chlorine at the diaphragm, and sodium chloride will be regenerated in the cathode compartment. The mechanical loss of chlorine would be made up by the addition of salt in the anode compartment. (1,137,874, May 4, 1915.)

Electrolytic Processes

Electrolytic Production of Caustic and Chlorine.—
A patent issued to Mr. WILLIAM M. JEWELL and assigned to the Chloride Process Company of Chicago, Ill., describes a combination of gravity and diaphragm cells. In this cell for producing chlorine and caustic solution from brine, the anode liquor is heavier than the cathode liquor, and is drawn off gradually from beneath the cathode liquor which remains practically undisturbed. This is done for the purpose of keeping the solution around the anodes in motion in order to prevent formation of hypochlorite and chlorate. A longitudinal section and cross-section on end of this cell is given in Fig. 5. The cathodes are the same as the anodes with the exception of being shorter. The cathodes are represented by 23, the anodes by 19; 18 is a partition separating the anode chamber from the cathode chamber and 17,17 are other partitions dividing the whole cell into single sets. A is the chamber for caustic solution, B contains the fresh electrolyte, a saturated solution
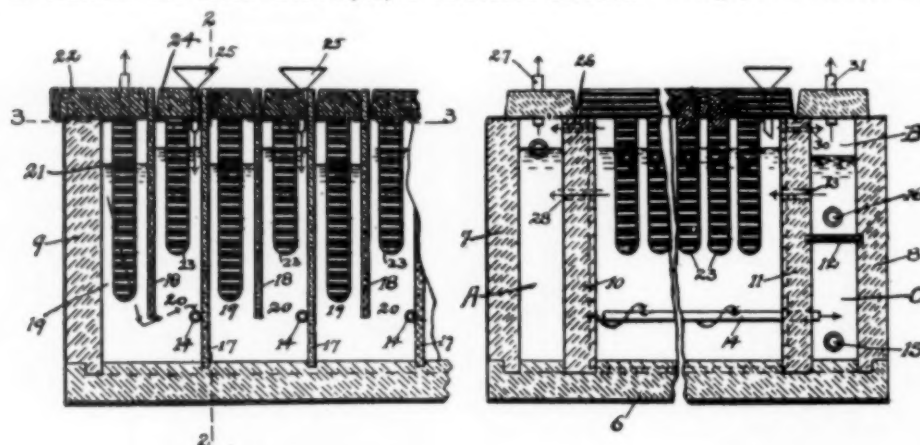

FIG. 5—ELECTROLYTIC CELL FOR CAUSTIC SODA AND CHLORINE

of brine, and C contains the spent brine, which is conducted away and replenished; 14 is a pipe through which the anode liquor flows from the cathode compartment into C, the cathode liquor not reaching down as far as this pipe, 28 is a passage for caustic solution into chamber A; 13 is a passage for conducting new electrolyte into the anode chamber, 12 is a partition separating chambers B and C. "By circulating the anode liquor, a very rapid rate of flow can be maintained without adding any appreciable amount of salt or chlorine to the cathode products, and I am able to obtain very high efficiencies both in chlorine and caustic soda production. By using anode and cathode elements arranged vertically, I also obtain much better results than when horizontal electrodes are used, as the electrode area being substantially vertical the gaseous products of the electrolysis are very readily eliminated." (1,145,-593, July 6, 1915.)

Electrolytic Purification of Liquids.—An apparatus for the electrical purification of milk is described in a patent issued to Mr. JAMES L. GOUCHER of New York, N. Y., and assigned by him to The New York Conveyancers Company. The feature of the apparatus is the use of vessel-shaped electrodes. The milk flows through the apparatus at a rate which is mechanically controlled. The electrical treatment is claimed to render the milk pure and sterile, and to generally improve its qualities. (1,145,862, July 6, 1915.)

An **electrical method of treating lumber**, which is claimed to greatly shorten the time of seasoning and protect the lumber from bugs and insects, is described in a patent of Mr. JOHN P. SULLIVAN of Memphis, Tennessee. Electrodes are connected to the timber in such a way that the current flows along the grain. A compound consisting of salt, bluestone, alum, indigo-blue and water, applied to the surface of the wood, before applying the electrodes, is claimed to aid in the conduction of the current. The dynamo should have a capacity of 110 volts and 30 to 40 amperes. (1,146,212, July 13, 1915.)

An **electrical controlling device** which utilizes the variable conductivity of solutions is patented by Messrs. WALTER J. PIKE and ROY J. SUTTON of Grand Rapids, Mich. In this device, which depends for its action upon the principle of the Wheatstone bridge, a solution of low conductivity may be passing through the apparatus and it may be desired to have a solution of a higher conductivity emerge. By so setting the apparatus that it is balanced when the desired solution emerges, any solution of lower conductivity sets up a current in the bridge, which closes a switch and operates a valve which supplies the necessary ingredients to bring the solution up to the required conductivity. The solutions themselves are, of course, parts of the bridge connections. (1,145,-509, July 6, 1915.)

Chemical Engineering

Water Treatment.—An invention relating to the prevention of corrosion and pitting in steam boilers is patented by Mr. CHARLES HAYTHORPE of Kennington, London, England. Zinc plates as heretofore used for this purpose have proved inefficient in that they do not prevent grease deposits or incrustations, and their effect is only local. The present invention contemplates the use of plates of zinc and carbon which are maintained in close and intimate contact, forming an efficient galvanic couple, and are also arranged in good metallic contact with the boiler. It is claimed that apparatus constructed in accordance with the invention has been found sufficiently intense in its action to remove old scale and incrustation in boilers already used. Economy in cost of 30 per cent to 40 per cent is effected since fewer plates are required than with other types. (1,127,360, Feb. 2, 1915.)

Synopsis of Recent Chemical and Metallurgical Literature

Chemical Engineering

Sugar-House Evaporating Apparatus.—Bulletin 149 of the Agricultural Experiment Station of the Louisiana State University and A. & M. College (Baton Rouge, La.) relates to "performance tests of sugar-house heating and evaporating apparatus." The author is Prof. E. W. KERR, who was assisted by Messrs. J. F. GUNTHER and W. A. TOLSTEN. The first part of the Bulletin contains an account of laboratory experiments made in continuation of the author's former researches of which a very full account was given in our Vol. XI, pages 333 and 611 (June and November, 1913). The final results of the laboratory work are summed up as follows:

The temperature conditions in the steam compartment

are very erratic and changeable, especially with very low steam pressure.

Air or other incondensable gases in the heating steam greatly reduce the heat transmission even with relatively low vacua. The coefficient of heat transmission* varies according to the equation $U = C(P_s/P_t)^n$, in which C is a constant, P_s the partial pressure of the steam and P_t the total pressure. The value of n seems to lie somewhere between 3 and 4. The presence of air pockets may be conveniently determined by means of thermometers in the steam compartment; good circulation and distribution of steam are important in preventing them.

The loss in heat transmission due to hydrostatic head is considerably in excess of the theoretical, and this excess is greater for short tubes than for long tubes. The loss with varying heads, other conditions being equal, varies according to a straight line formula.

Other conditions being equal, the lower the "temperature level" the smaller the coefficient of heat transmission; in other words, the lower the temperature and density of the heating steam the smaller the coefficient. The coefficient of heat transmission varies according to the equation $U = 2.25 + 17,500D$, where D = density of heating steam in pounds per cubic foot.

Increasing the density of the boiling liquid causes a loss in heat transmission due to the decrease in temperature fall according to the equation $y = CD^{2.1}$, in which C = a constant and D = density in degrees Brix. The total loss due to the density of the boiling liquid seems to be in excess of that due to loss of temperature fall. This may be due to lower velocity of circulation.

The vapors evolved from liquor of high density or from liquor under hydrostatic head are superheated.

The entrainment was less in a double-tube calandria than in the standard calandria, probably for the reason that the spouting action was lacking.

The coefficient of heat transmission seems to be independent of the quality of the steam. Superheated steam gives coefficients as high as those obtained with saturated and moist steam.

Within reasonable limits the coefficient of heat transmission seems to be independent of the temperature fall.

The coefficient of heat transmission is independent of the temperature of juice feed.

The coefficients of heat transmission obtained in the small laboratory apparatus were much higher than are obtained in full-size evaporators. This is probably due to better circulation, cleaner heating surface, better steam distribution and the relatively large condensation pump used with the laboratory apparatus.

The great temperature fall required in the last body of a multiple-effect evaporator is due to the combined influence of greater amounts of air, steam of lower density, liquid of higher density, also, in many cases, more foul heating surfaces than in preceding bodies.

The downtake or circulation tube was shown to increase heat transmission materially. Long tubes give better results as to heat transmission than short tubes, due to better circulation.

*For definition see our Vol. XI, p. 334.

The tests show that the double-tube and the baffle-plate calandria gave greatly increased heat transmission as compared with the standard types tested, and indicate that attention to steam distribution and the removal of incondensable gases is very important.

The second part of the Bulletin gives an account of large-scale tests of the capacity and economy of evaporating and heating apparatus in sugar factories in four chapters, relating to multiple-effect evaporators, vacuum pans, juice heater, and condensers. Rather full extracts from the chapter on vacuum pans are given elsewhere in this issue.

Air-Lift Pumping.—A resumé of air-lift pumping is given in an article by Mr. PAUL H. BERGGREEN in the *Sibley Journal of Engineering* of Cornell University for May, 1915. For this important mechanism of the hydraulic engineer, which is becoming of such importance in chemical and metallurgical practice, no accurate for-
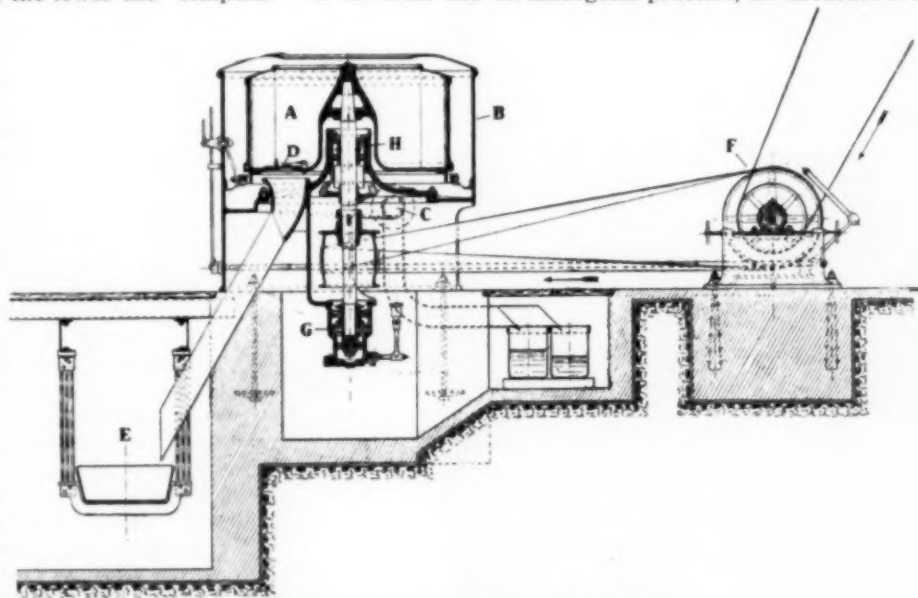

FIG. 1—UNDER-DRIVEN CENTRIFUGAL

mulæ are available because of the numerous variables encountered. A great deal more experimental work is needed in order to establish accurate details. "It was at first supposed that in all air lifts the water was discharged because of aeration in the eduction pipe, due to the intimate commingling of air and water, as the rising air bubbles gave a constant discharge of air and water. This may be true in the case of very moderate lifts, while with a sufficient head and a large volume of water, piston-like layers of air and water are formed." The many different services to which this pump may be applied are its chief cause of success. In places where ordinary pumps cannot be used, such as pumping from great depths where fine sand is encountered, and also in such cases as conducting water a great distance and subsequently elevating it, the air-lift pump has shown itself to be very useful and its future seems to lie in the direction of high lifts, in which it shows a remarkable ease of operation wherever there is a sufficient amount of submergence available.

Centrifugals.—G. BARNICK describes in *Chemische Apparatur*, June 25, improvements to centrifugal machines which are of special interest in view of the important part these machines now play in industrial chemistry. Ball-bearing machines, driven from beneath are described, together with some of the uses of centrifugals, main features of construction, and the exacting requirements which they have to meet. The advantages of the under drive, over the over-head drive, are

claimed to be: freedom of operation in charging, ease of access to driving mechanism, and the impossibility of contaminating the product with oil. On account of the high velocity (1000-2000 r.p.m.) at which a centrifugal runs, the construction must be very excellent and only the best materials must be used. The maximum load must not exceed the strain which the metal can stand. Lately, spindles have been equipped with ball bearings and this method is finding increasing application. A novel application of the centrifugal is its use in dewatering tar, the tar being freed of its water down to 1 per cent, so that it is directly applicable to felt roofing manufacture. In centrifugals for treating vaccinating serum a speed of 2000 r.p.m. is used, and the machine for this purpose must be constructed to stand a speed of 3000 r.p.m. For materials containing acid, the inside construction is made of lead, tin, copper or sometimes covered over with rubber. A machine of the under-driven type is shown in Fig. 1, in which A is the inside rotating cylinder, B the outside stationary frame, C the discharge pipe for liquid, D the discharge for solid into the receptacle E. F is the driving pulley, G shows the ball bearings, and H is an ordinary collar bearing.

Alum for Water Purification.—In an American Chemical Society paper read at the New Orleans meeting (abstracted in *Science*, July 16), C. P. HOOVER described the manufacture of alum at the Columbus water softening and purification works. The process most generally employed to-day for coagulating and purifying water contemplates applying to the water under treatment a solution of aluminum sulphate. The cost of this chemical varies from $17 to $20 per ton. A plant for making alum has recently been built and put in service at the Columbus water purification plant. This is the first plant of its kind ever built at a water purification works for making alum to coagulate water, and, although it has only been in operation a short time, it has been a success both technically and economically. The process is short, simple, and inexpensive, because it consists simply in boiling bauxite with sulphate acid and applying the resultant solution to the water under treatment, thus eliminating five distinct steps in alum-making, namely, filtering, concentrating, crystallizing, grinding and redissolving. An investment of $12,000 was required for its construction, and it has been conservatively estimated that $6,000 per year will be saved the city in the cost of alum. Between 800 and 1000 tons of alum will be manufactured during the coming year at a cost of about $10.50 per ton.

Temperature of Hydrochloric Acid Formation in Evaporation of Magnesium Chloride Solutions.—Dr. H. HOF in *Chemiker Zeitung*, June 23, 1915, gives the results of a research which confirms the assertion of Casaseca, that when a pure magnesium chloride solution is evaporated the separation of hydrochloric acid takes place at 157 deg., the boiling point of $MgCl_2.6H_2O$. A paraffin bath was used for the evaporation, and it was noticed that if the surface of the solution was below the surface of the paraffin, an over-heating occurred, which caused the formation of acid at 107 deg. When the surface of the magnesium chloride was kept above the surface of the paraffin, in most cases the water could be almost completely evaporated without any formation of acid. It was also noticed that in distilling the magnesium chloride by-product from potassium chloride manufacture, the separation of acid took place at a lower temperature. This was attributed to the presence of magnesium sulphate.

Gold and Silver

Refining Gold by Miller's Chlorine Process.—In the July *Bulletin* of the Canadian Mining Institute, Mr. RALPH PEARSON describes the process of refining gold

at the Royal Mint, Ottawa, by the use of chlorine. The process is best adapted to the removal of silver and base metals from gold, even if present in large quantities. The requirements for the Miller process are: a constant supply of chlorine gas at a pressure of not less than 5 to 6 lb. per sq. in.; melting furnaces using either coke or oil for fuel; condensing chambers; and suitable pots, tongs, molds, etc. At the Ottawa mint the chlorine is delivered from steel cylinders holding 100 lb. liquid chlorine at a pressure of 97 lb. per sq. in. at 20 deg. C. The cylinders are housed in a cupboard that is ventilated by connection with the furnace flue leading to the condensing chamber and a pipe communicating with the outside air. The connections between cylinders and crucibles are lead pipes, rubber tubing and glass stop-cocks. The desired pressure is obtained by connection with a lead receptacle like a Wolff's bottle, the third neck holding a lead pipe connected with a glass tube which is in turn connected with an enlarged lead bulb, similar to a large pipette. The lead receptacle holds sufficient water to give a column 11 ft. in height, corresponding to a pressure of about 5 lb. per sq. in. Should the pressure exceed this amount, the water is forced up into the lead bulb and the gas escapes outside the building.

From 500 to 700 oz. of the metal to be refined is charged into a clay pot and placed in the plumbago crucible in the furnace. Borax is added to form a cover about $\frac{3}{4}$-in. deep. The clay crucible has a clay cover with a slot to permit the passage of a clay pipe stem through which the chlorine is delivered to the bottom of the molten mass in the crucible. The chlorine is admitted cautiously until it passes with a steady pulsation. Dense fumes of copper and lead chlorides appear and practically all of the chlorine is absorbed. Later silver chloride is formed and floats above the gold and beneath the borax. The finishing point of the process is judged by the brown stain formed on a cold piece of clay pipe held in the fumes issuing from the pot. The fumes resulting from the chlorination and from the products of combustion are all carried through condensing chambers to a washing tower.

When the chlorination is complete the pot is withdrawn from the furnace and allowed to cool until the gold sets. Then the borax and silver chloride are poured off and separated when cold. The silver chloride is freed from some contained gold by remelting and treating with sodium carbonate, sprinkling the latter on the surface of the molten chloride. Globules of silver are reduced and sink to the bottom, carrying gold with them. The gold-free silver chloride is then treated with hot water to remove copper, which is separated from solution by precipitation on iron. The silver chloride is then reduced to metallic silver by contact with iron plates in a hydrochloric acid solution, and finally washed and melted. The fineness of the gold produced by the process will average 995, the silver fineness varies from 995 to 998. The time required varies with the amount of silver and base metals present in the gold. Thus an ingot weighing 500 oz. and containing 140 oz. base and 80 oz. silver, required 7 hours.

Treatment of Arsenical-Antimonial Sulphide Ore.—A record of experimental and practical work on the cyanide treatment of a gold ore containing arsenic and antimony sulphides is reported by Messrs. K. B. MOORE and H. R. EDMANDS in the February *Journal* of the Chamber of Mines of Western Australia. A representative analysis of the ore follows: Insoluble, 70.04 per cent; iron, 8.3; antimony, 0.21; arsenic, 0.96; sulphur, 5.62; carbon dioxide, trace; magnesia, 2.74; alumina, 2.02; lime, 3.36; alkalies, water, etc., 6.75; total, 100.00 per cent.

A vast amount of research work was done in an effort to find a suitable method of treatment. Amalgamation and cyanidation yielded only about 50 per cent. of the gold. Concentration gave still poorer results, and the tailing yielded less than half its gold to cyanidation. Flotation gave disappointng results. Bromo-cyanide was tried without success, and preliminary treatment with NaOH did not improve matters much, as some of the gold was associated with arsenic and was not liberated. Experiments with roasting and cyaniding indicated that roasting was an essential, and a plant has been constructed in which the ore is dried, ground in a Krupp ball mill and roasted in an Edwards duplex furnace.

After this treatment the ore is mixed with oxidized ore and given the usual cyanide treatment.

It has been found unnecessary to give a perfectly sweet roast in order to get maximum extraction. Roasting must be carried far enough to liberate all gold from the sulphide, and no unaltered pyrite or arsenopyrite must be left. Ore carrying $3\frac{1}{2}$ per cent to $4\frac{1}{2}$ per cent sulphur retains from $\frac{1}{2}$ per cent to 1 per cent after roasting, about two-thirds of which is soluble in Na_2CO_3. Samples taken half way down the roaster have given as good extraction as those taken from the discharge. The addition of lead acetate is a necessity to remove soluble sulphides.

The roast cannot be tested satisfactorily by the ordinary iodine absorption method. Owing to the frequent presence of antimony in the roasted product, which separates out on acidifying the soda extract, iodine does not give a sharp end point. The method used is to boil 20 g. of ore in 100 cc. of 5 per cent soda for one minute, decant 50 cc., acidifying with H_2SO_4 and titrate with $N/30$ $KMnO_4$. While this is not altogether satisfactory it gives a more definite end point and concordant results. If less than 10 cc. permanganate is required the roast is considered fair, but often a roast with far more reducing power gives quite as good extraction.

The loss of gold by volatilization has not been great, amounting to from 1s. to 2s. per ton on ore containing 53s.

In fact, the loss rarely exceeds 1s. 6d. or under 3 per cent.

Plant solution is tested for reducing power by taking 50 cc., acidifying and titrating with $N/30$ permanganate. Usually from 25 cc. to 50 cc. of permangante is decolorized.

Fine grinding is essential to a good extraction. The average screen test shows only about 15 per cent plus 150-mesh. A thin pulp of about 35 per cent solids gives better results than one of 45 per cent solids.

Zinc shavings were first used for precipitation, but with poor results. The authors devised a system of zinc-dust precipitation which they installed and operated with great satisfaction. The extraction has averaged over 84 per cent, with a residue of 7s. per ton. Cyanide consumption does not exceed 1 lb. NaCN per ton. The total cost is 9s. per ton, distributed as follows: Breaking and transportation, 8d.; drying, 8.5d.; ball milling, 1s. 8d.; roasting, 2s. 6d.; fine grinding sand, 6d.; agitation and vacuum filtration, 2s. 4d.; precipitation and smelting, 6d.; tailing disposal, 1.5d.

Copper

British Columbia Copper Company's Smelting Plant. —In a paper presented to the American Institute of Mining Engineers, Mr. FREDERIC K. BRUNTON describes the plant and smelting practice of this company, which operates at Greenwood, B. C. We abstract the following condensed data.

RÉSUMÉ OF FURNACE OPERATING DATA

Tons smelted per day	2,250.0
Tons smelted per square foot of hearth area, average	6.62
Tons smelted per square foot of hearth area, maximum	8.70
Tons smelted per man per day	35.70
Cu on charge, per cent	0.8 to 1.2
Cu in matte, per cent	30.0 to 45.0
Cu in slag, per cent	0.22 to 0.27
S on charge, per cent	2.00
S burnt off, per cent	85.00 to 90.00
Coke used on charge, per cent	12.00 to 14.00
Coke ash, per cent	20.00 to 28.00
Blast per cubic feet per minute	25,000
Blast, temperature	Atmospheric
Cooling water for jackets, gallons per minute	2,500
Men per 8-hr. shift	21.0
Matte, per cent of total charge	1.65
Matte, specific gravity	5 to 0
Slag, per cent, SiO₂	38 to 45
Slag, per cent Fe	13 to 20
Slag, per cent, CaO	20 to 26
Slag, per cent, Al₂O₃	6 to 9
Slag, specific gravity	3 to 2

TOTAL COSTS

The Following Costs Do Not Include Overhead Expenses, Depreciation, or Insurance

Cost per ton of smelting ore to matte	$1.18
Cost per pound of copper of converting matte to blister	0.0048
Cost per ton of copper of converting matte to blister	9.60
Cost per ton of smelting ore to blister copper	1.23
Cost per ton of copper to produce blister copper	0.105
Cost of coke per ton of ore smelted to matte	$0.851
Cost of flux per ton of ore smelted to matte	0.114
Cost of labor per ton of ore smelted to matte	0.15
Cost of power per ton of ore smelted to matte	0.033
Cost of supplies per ton of ore smelted to matte	0.03
	$1.178
Cost of coke per ton f.o.b. smelter bins	$6.00
Cost of flux per ton f.o.b. smelter bins	2.75
Cost of power per kilowatt-hour	0.0065

Concentration

Flotation Tests on Bisbee and Cobalt Ores.—An investigation of some of the variable factors in flotation undertaken by Mr. HERBERT J. FRENCH is published in the Columbia School of Mines *Quarterly*. The factors considered were (1) oil, variety and amount; (2) amount of sulphuric acid; (3) agitation, length of time and speed; (4) temperature of solution, and (5) size to which ore is crushed.

The oils tested were fish, sperm, whale, corn, cylinder, pine, pine-tar, lard and cottonseed.

The ore from Bisbee, Ariz., contained copper as chalcopyrite, chalcocite and malachite. It analyzed as follows: Insoluble, 65.1 per cent; iron, 10.9; lime, 0.9; alumina, 0.28; sulphur, 12.7; total copper, 6.04, of which 1.7 per cent was soluble in dil. hydrochloric acid. The conclusions reached as a result of the tests were: Pine-tar oil of 0.98 sp. gr. was the best frothing agent, collecting more sulphides per unit of volume than the other oils tested. Sulphuric acid in quantity approximating 0.3 per cent by weight of the water in the pulp seemed to be necessary to increase the selective action of the oil and the total extraction. Extraction improved with increase in temperature, the best condition being at 65 deg. C. Nothing shorter than 10-min. periods of agitation gave efficient flotation. Sizing the ore was necessary to secure the best results, which were obtained from material ground to from 100 to 150-mesh. The greater losses occurred in particles larger than 65-mesh.

The Cobalt ore was from the Coniagas mine, containing about 13 oz. silver per ton, mainly in the form of antimony, arsenic and sulphur compounds, with some native silver. With this ore pine-tar oil proved the most efficient flotation agent. Adding the oil in successive portions and giving longer periods of agitation gave as good an extraction with less consumption of oil.

The Silver King Coalition Mines Company is to add flotation to its standard concentrating practice at Park City, Utah. The new plant will have a capacity of 600 tons per day, and is expected to be in operation within sixty days. The Callow pneumatic process will be used.

Low-Pressure Oil-Burning Metallurgical Furnaces

Economy and efficiency in modern metallurgical work have been greatly promoted in recent years by improvements in accessory apparatus for the laboratory and mill. As an example of such apparatus may be mentioned the improved line of Case metallurgical furnaces, manufactured by the Denver Fire Clay Company, Denver. Col. These furnaces have been used with marked success in the heat treatment of metals, for assaying ores and refining cyanide precipitates, for annealing and enameling, and for melting brass and other foundry metals.

An important feature of the Case furnaces is the low-pressure oil burner, illustrated in Fig. 2. Oil is introduced usually by gravity (although high pressures can be used), and issues from the central part of the burner in a cone spray diverging at an angle of 45 deg. All air for combustion also goes through the burner, issuing from two annular rows of holes and forming a cone of jets converging at an angle of 60 deg. This produces an excellent mixture of oil and air which enters the combustion chamber of the furnace through a small opening of the same size as the face of the

The tilting furnace illustrated, embodies many conveniences which relieve the operator of a vast amount of hard labor and protect him from the heat while pouring the charge. Between the steel shell and fire-clay lining is a layer of refractory insulating material which acts as a cushion during the expansion and contraction of the furnace, and conserves heat. The interior lining is of fire-clay tile, molded with numerous projections in the form of checker work, which support the crucible laterally. The crucible is molded with a lip that forms a pouring spout. A fire-clay stool in the combustion chamber supports the crucible from the bottom, the upper surface of the stool being channeled to permit circulation of heat around the bottom of the crucible.

The combustion chamber is below the crucible. The flame enters tangentially and complete combustion occurs almost instantaneously. The crucible and fire-clay
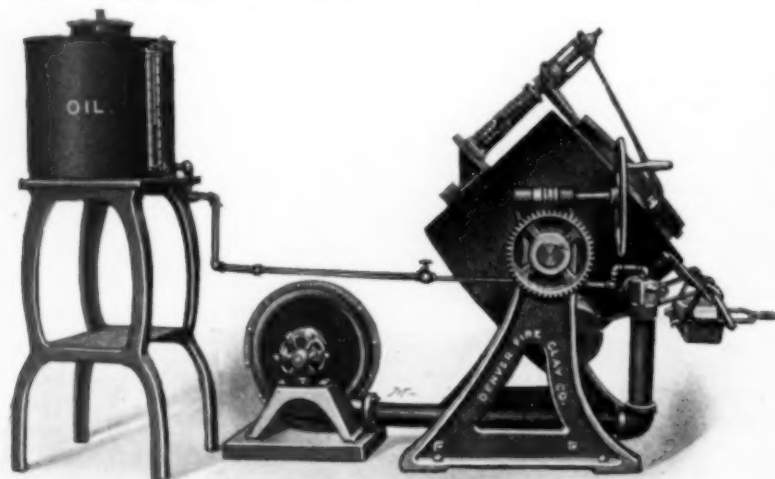

FIG. 1—OIL-FIRED TILTING CRUCIBLE FURNACE

burner, thus excluding auxiliary air. Both oil and air are under valve control, so that a mixture of proper proportion for complete combustion is easily maintained under all conditions. Air is supplied to the burner by a direct-connected motor-driven blower which runs at 3600 r.p.m. and delivers 3000 cu. ft. of air per minute at a pressure of about 6 oz. The fan has 20 blades of aluminium mounted in a cast-iron casing.

The advantages claimed for the low-pressure burner over those operating under high pressure are the freedom from noise, economy of fuel, control of air supply, perfect combustion without formation of carbon, and reduced wear and tear on the crucible and other parts of the furnace. The poor features involved in needle valves are entirely eliminated.

The burner is applied to a variety of furnaces constructed for special purposes. The one shown in Fig. 1 is a crucible furnace of the tilting type, with swinging frame to carry the mold wnile pouring and a cover that can be moved either vertically or laterally. This type of furnace is used for melting brass and other foundry metals, refining cyanide precipitates, and melting gold and silver bullion. Other types of furnaces are built for the heat treatment of steel, for annealing and enameling, and for assaying.

FIG. 2—FACE OF LOW-PRESSURE OIL BURNER

lining become highly heated as the gases of combustion rise through the checker work, and the lining radiates heat uniformly to all parts of the crucible.

The motor for the blower consumes $1\frac{1}{2}$ kw. per hour. Oil consumption varies from $\frac{3}{4}$ gal. to 2 gal. per hour, depending on the nature of the work and the temperature required.

Numerous records for economy and efficiency have been established by Case furnaces. An assay furnace running 129.9 burner-hours consumed 179.8 gal. of 26 deg. Baumé fuel oil, or only 1.39 gal. per burner-hour. In another case the cost of fuel for assaying was reduced 60 per cent by the adoption of a Case furnace. An interesting comparison of fuel consumption under high-pressure and low-pressure air gave the following results: With high-pressure air 3200 gal. of oil was consumed in a month, firing three muffles; with low-pressure air the consumption was but 800 gal. for a month, and four muffles were fired.

Equally good records have been made for the tilting crucible furnace. In melting cyanide precipitate one of these furnaces used only 20 gal. of oil at 17.5 per gallon to accomplish the same results formerly attained by the combustion of 1000 lb. of coke at $16 per ton. The value of the slag was reduced from about $200 to $12 per ton. For remelting 1500 oz. of gold bullion the oil consumption at one mill was 1¾ gal. oil at 6 cents per gallon, as against the former use of 140 lb. coke at 1.12 cents per pound. In addition the time of operation was greatly reduced and the life of crucibles doubled. Another record made was the melting of 800 lb. cyanide precipitate in one hour with a fuel consumption of 1⅞ gal. of oil. In this case a saving of 66 per cent was made in fuel cost as compared with former practice.

Calibration Curve for Horizontal Cylindrical Tanks

Wherever horizontal cylindrical tanks are used for storage of fuel oil or other liquids, a simple method of calibrating becomes desirable. In Fig. 1 we show a
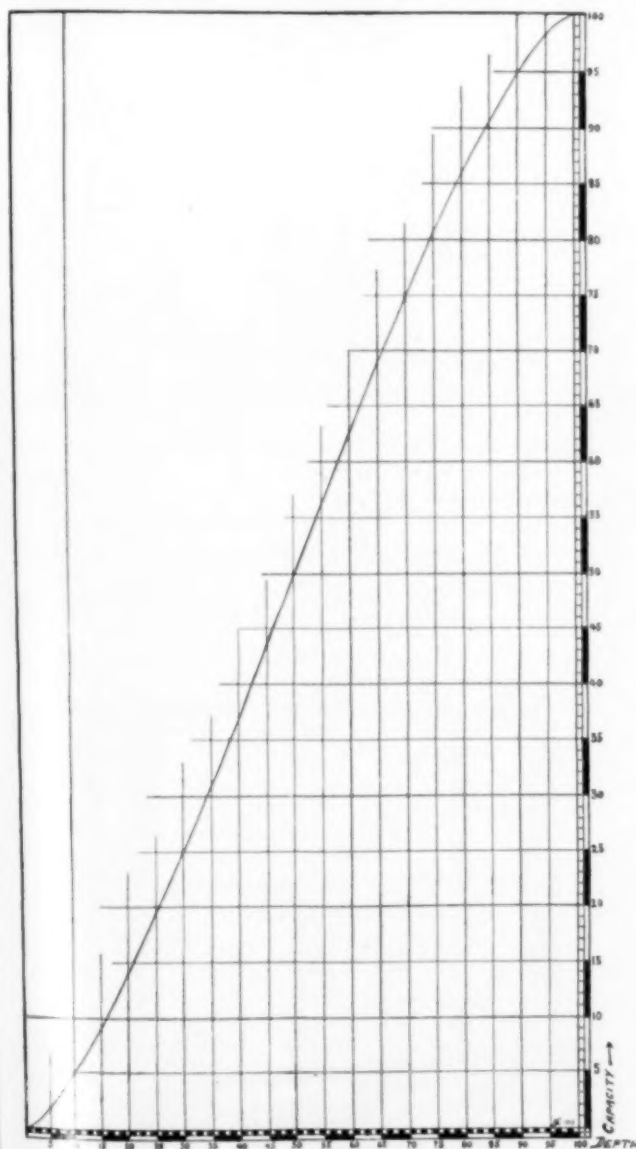

FIG. 1—CALIBRATION CURVE FOR HORIZONTAL CYLINDRICAL TANKS

calibration curve for such tanks of any dimensions, devised by Mr. H. J. Elson, Universal Iron & Supply Company, 325 Locust Street, St. Louis, Mo. The curve as here presented is somewhat reduced in size, but a full

size curve can be secured on application at the address given.

The horizontal scale in Fig. 1 indicates percentage of total depth, and the vertical scale percentage of capacity. By entering the horizontal scale at the bottom with percentage of total depth, and rising to the curve, the percentage of total capacity corresponding to depth can be read at the right.

The total capacity of the tank in gallons equals the square of the diameter in feet multiplied by the length in feet, multiplied by 47, divided by 8; or, equals the square of the diameter in inches multiplied by the length in inches, multiplied by 17, divided by 5000.

To adapt the curve to a particular tank, a scale of gallons may be written in the column at the left by entering at the top, corresponding to 100 per cent, the capacity of the tank found by the above rule, and dividing it proportionately down to 0. The depth of the liquid in the tank may be taken in percentage of total depth by dividing into 100 parts a line or rod of length equal to the diameter of the tank, and then the scale can be read directly by way of the curve to gallons on the left. Or, a scale in feet and inches corresponding to the tank diameter may be put on the 0 to 100 depth scale, and the depth of liquid in the tank read from a line or rod divided in feet and inches.

Titanium-Aluminium Bronze Castings

BY W. M. CORSE

Practically every mechanical engineering handbook contains references to aluminium bronze, describing it as having the properties of good steel and in addition great resistance to corrosion. When the engineer is interested, however, in this metal and searches for a source of supply, he finds that rolled aluminium bronze can be bought from several reputable manufacturers, but he immediately encounters difficulty in securing it in the form of castings. Further inquiry develops the fact that while some foundries have made castings of this metal in the past the difficulties involved are so great that its manufacture has been practically discontinued.

The Institution of Mechanical Engineers of Great Britain, realizing the valuable properties of the copper aluminium alloys for engineering purposes, presented its eighth report to the Alloys Research Committee on this subject in 1907. This report contains a very exhaustive study of the metal commonly known as aluminium bronze and calls particular attention to the facts that it resembles a Swedish bessemer steel of 0.35 carbon to a remarkable degree and that the castings have practically the same physical properties as rolled material; this is a unique exception to the general rule.

That castings of copper and aluminium have the strength of steel and show up equally well under alternating stresses and impact tests is a fact worthy of more than passing notice.

The 10 per cent aluminum bronze has the following properties:

Ultimate tensile strength (standard test bar), 70,000 per square inch.

Elongation in 2 in., 20 per cent.

Hardness Brinell scale (500 kg.), 100.

Specific gravity, 7.5.

Weight per cubic inch, 0.27 lb.

Permanent compression under 100,000 lb. load per square inch, 12 per cent.

Coefficient of friction (Cornell University bearing testing machine), 0.0018.

It is practically non-corrodible in sea water and has a high resistance to corrosion in such chemical liquors

as the sulphite liquors in the paper industry and the tanning liquors in the leather industry.

On account of its high aluminium content the metal is approximately 16 per cent lighter than phosphor bronze and 10 per cent lighter than manganese bronze. When it is remembered that the strength of this metal is practically the same as manganese bronze and its wearing properties at least equal to phosphor bronze, the possibility of reducing weight through its use is certainly interesting from an engineering standpoint.

This metal is also analogous to steel in that it can be hardened by heat treatment. This is a very useful and unusual property for a bronze alloy to possess.

Recent letters from several prominent British manufacturers indicate that very little has been done in casting this material commercially in Great Britain. Similar inquiries in the United States reveal the fact that while aluminium-bronze castings are offered in some instances, either the quality or the price is not all that may be desired, thus practically barring this valuable metal from engineering specifications.

It is well known that small accounts of certain elements exert a profound influence on the properties of iron and steel, and it is, therefore, reasonable to expect that similar influences might be exerted upon certain copper alloys.

On this theory the Titanium Alloy Manufacturing Company of Niagara Falls, N. Y., put one of its research men on this problem with the result that it has found that small additions of titanium or its compounds exert a like profound influence on the properties of certain copper alloys, among which are the aluminium bronzes. After three years of careful research it was decided to build a foundry to manufacture bronze castings and to specialize on the aluminium bronzes. This is an important industrial achievement, and one which will enable the engineer to avail himself of these metals which have proven to be so important for many industrial uses.

That such an alloy can now be made commercially at a reasonable price is also notable.

Numerous uses immediately suggest themselves for castings having the properties enumerated above. Among these may be mentioned gears and gear wheels for high speeds and heavy loads, bearings for high-speed machinery, marine fittings exposed to sea water and parts exposed to the action of chemical liquors, parts requiring great strength and resistance to shock, and castings to withstand high pressures.
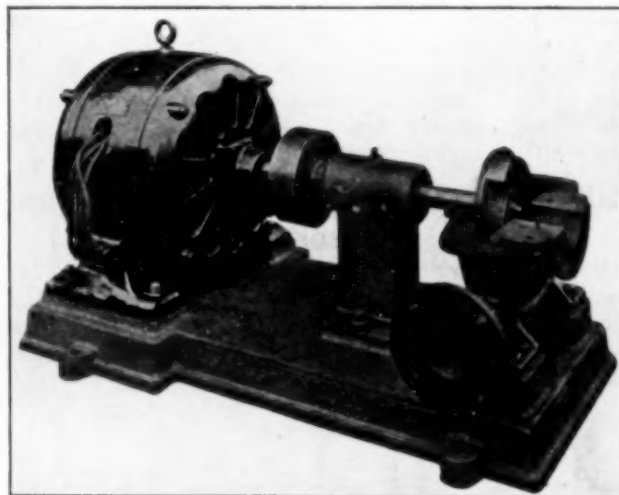
Centrifugal Pump for Thick Liquors

The cut shown herewith shows a high-efficiency type of centrifugal pump suitable for handling liquors containing large amounts of solids, chemicals, wood pulp, or gun cotton pulp solution. The impeller has very wide passages in proportion to its capacity, but its design is such that in spite of these wide passages a high efficiency is obtained, while the pump characteristic is such that no heavy overload is produced on the driving motor when the pump operates at pressures below the rated pressure, which is a condition occurring in most pumps made to handle thick liquors.

The pump has a horizontally parted case which facilitates access to the interior for convenience of inspection, cleaning and repairs. The pedestal bearing is equipped with two ball bearings operating in a housing packed with a non-fluid oil or light ball-bearing grease. They are so arranged as to carry not only the radial load but any thrust that may come on the pump in either direction. The impeller, however, is provided with a balancing ring so as to secure hydraulic balance.

On account of the large passes through the impeller,

the pump is also very suitable for pumping sewage, as solids which would ordinarily choke up a small capacity impeller pass freely through the pump.

The particular pump shown in the adjoining illustrations is driven by a single-phase motor and for the purpose of keeping down the starting current a special centrifugal clutch coupling is provided, which allows the motor to come up to speed before the load comes on the

CENTRIFUGAL PUMP FOR THICK LIQUORS

motor. Either this type of coupling or the standard type of flexible coupling with steel pins and rubber bushings is furnished.

This type of pump is particularly suited for handling the nitrated cotton liquors in connection with the manufacture of gun cotton.

The pump is manufactured by the D'Olier Centrifugal Pump & Machine Company, Philadelphia, who make a full line of centrifugal pumps as well as centrifugal machines used for nitrating cotton and for general chemical purposes.

A New Assay Balance

An assay balance operated like a typewriter is a novel development in scientific instruments that is being
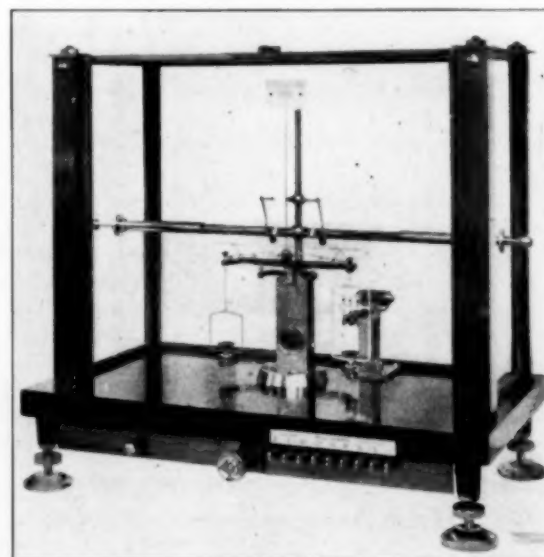

FIG. 1—A NEW ASSAY BALANCE

brought out by the Mine & Smelter Supply Company, Denver. Col. This balance is the invention of Mr.

Wilfrid Heusser, of Salt Lake City, Utah, who has for some time past been manufacturing a line of metal-case balances.

The feature of the instrument that marks a distinct advance in balance construction is the method of handling the weights, placing them on or removing them from the pan hanger. By merely pressing one or more keys which are in front of and outside the balance case, any weight or combination of weights can be deposited on the pan hanger. The balance is shown in Fig. 1, and a detail of the apparatus in Fig. 2.

The weights themselves consist of perforated discs, made of aluminium for the lighter and of platinum for
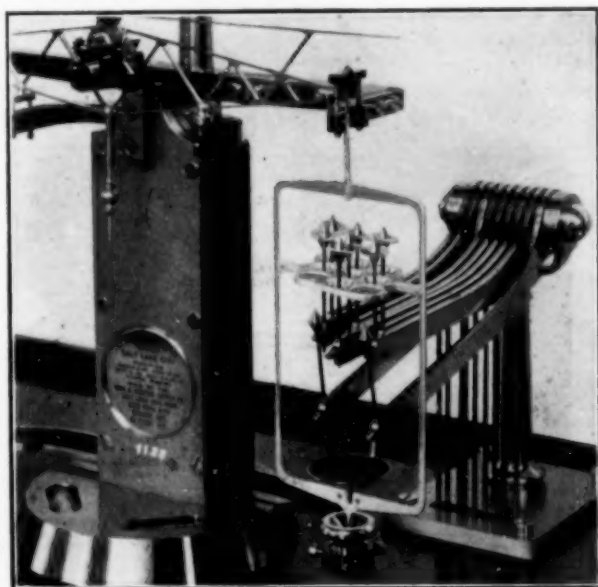

FIG. 2—MULTIPLE-WEIGHT DEVICE FOR ASSAY BALANCE

the heavier weights as is usually the case. Normally each disc is carried by one of a series of upright posts with conical tops, passing through a perforated horizontal frame which forms a part of the pan hanger. Each of these upright posts is operated by an individual key on a keyboard in front of the balance. On depressing a key, the corresponding upright post is lowered, and the weight, which is too large to pass through the perforation, rests on the pan hanger frame and registers its weight as though placed in the scale pan. In like manner, raising the key raises the upright post which, with its conical top, lifts the weight and removes it from the pan hanger frame. By this means any weight or combination of weights can be placed upon or removed from the pan hanger without opening the balance case. The device marks a distinct improvement over all previous forms of multiple-rider attachments, the object of which has been to avoid handling the weights with pincers as well as the opening and closing of the balance.

An analytical balance embodying the Heusser construction as to truss beam and metallic case has also been developed, and can be equipped with the same multiple-rider attachment just described.

Pan-Americanism

The Second Pan American Scientific Congress

BY GLEN LEVIN SWIGGETT

During the present year two great Pan American gatherings convene in Washington under the auspices of the Government of the United States. The first of these, the Pan American Financial Conference,

occurred the week of May the 24th, 1915. In this conference delegates from the Latin American countries conferred with representative bankers and business men from our nation at the Pan American Union, on invitation of the Secretary of the Treasury, on financial questions of pertinent interest that must have far-reaching beneficial results to Pan American banking and commerce.

Of greater interest to the professional world, however, is the Scientific Congress that will convene in Washington beginning December 27, 1915, and concluding its sessions on January 8, 1916. Through the splendid cooperation of the Latin American countries, the second Pan American Scientific Congress, likewise held under the auspices of the United States Government through the Department of State, bids fair to be not only thus far the greatest Pan American Congress, but the most important international scientific congress ever held in the United States. The first congress of this name was held in Santiago, Chile, in 1908. It had its origin in earlier Latin American Scientific Congresses; and at the time of the Santiago congress was enlarged through the generous initiative of the Latin American countries to include the United States. This congress was well attended by visiting delegates from the United States. On its adjournment, entirely unsolicited on the part of the latter, Washington was designated as the place of meeting of the Second Congress.

This honor has a singular appeal to our nation at this time. The present European war has brought the Western Hemisphere suddenly face to face with grave economic problems that invite the serious attention of scientists and experts in the various fields of applied science. The Scientific Congress will concern itself with the constructive discussion of these as well as with the contributions in the domain of pure science wherein great advance has been made since the last congress in Santiago, Chile. Science is comprehensively defined by the congress and includes, under nine heads, such main subjects as: Anthropology, Astronomy, Meteorology and Seismology, Conservation of Natural Resources, Agriculture, Irrigation and Forestry, Education, Engineering, International Law, Public Law and Jurisprudence, Mining and Metallurgy, Economic Geology and Applied Chemistry,* Public Health and Medical Science, Transportation, Commerce, Finance and Taxation.

Washington offers unusual advantages for a congress of this nature. It enjoys an enviable distinction among the world capitals for the keen scientific interest and investigation in its various Federal Bureaus, the varied and extensive nature of its libraries and museums, the beauty of its buildings and the growing importance of detached but semi-official institutions and bureaus engaged in work of international scope. Among these none occupy a position of greater importance than the Pan American Union, the governing board of which, composed of the diplomatic representatives of the participating Latin American countries with the Secretary of State of the United States as ex-officio chairman, has signally honored the Second Pan American Scientific Congress by authorizing the use of its beautiful building for the office and sessions of the congress. The board also, in response to the request of the President and Secretary of State of the United States, authorized to act as secretary-general of the Scientific Congress the Director-General of the Pan American Union, the Honorable John Barrett, who has doubtless done more than any one American in the establishment of commerce and comity among

*The chairman of this section is Mr. Hennen Jennings.

the republics of the western world; whose good fortune it has also been to see, through the seeming accident of war, the potential promise of his great work becoming realized so soon.

The Feasibility of Continuous Causticizing

This article will be devoted to a discussion of the feasibility of adapting continuous agitation and continuous counter-current washing to causticizing soda ash by means of lime, according to the equation

$$Na_2CO_3 + CaO + H_2O = 2NaOH + CaCO_3$$
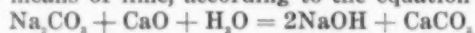
The application of these two features to metallurgical problems, especially in the cyanide treatment of gold and silver ores, has met with great success and it is believed that in other fields where the agitation of solids in liquids and the subsequent washing of the solids free from liquid containing dissolved substances is practised, the possibility of their use will be of economic interest.

Continuous operation invariably means lower labor costs and a high load factor, thus assisting in lower power costs and interest charges. Where the change from intermittent to continuous work does not sacrifice control of the operation, it results usually in allowing a large output of uniform nature.

From a mechanical standpoint the problems of a scheme for continuous causticizing are readily solved by the use of Dorr continuous thickeners and Dorr agitators.

The Dorr continuous thickener, Fig. 1, consists of a slow-moving mechanism placed in a suitable tank, by means of which the operation of settling may be made continuous through the removal of the settled material to a point of discharge and the prevention of the accumulation of solids in the tank.

It consists of a central shaft with radial arms equipped with scrapers to bring the thickened material to the discharge opening at the center of the tank by the slow rotation of the mechanism. The thick material may be
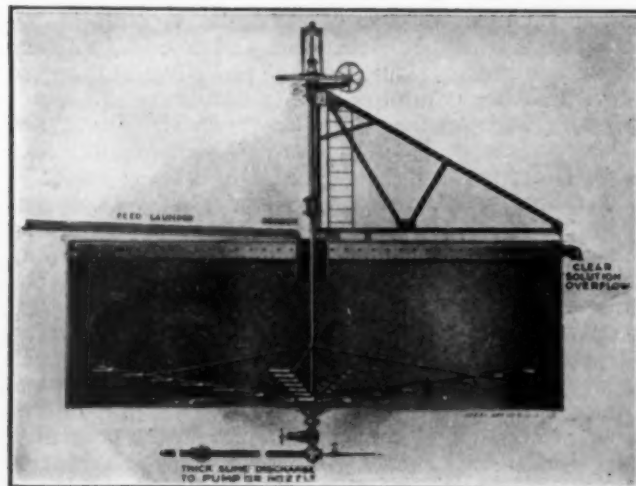

FIG. 1—CONTINUOUS THICKENER

discharged at this point into a launder, or piped to the side of the tank and raised by pump or other suitable means to the level of the overflow or higher.

The machine is arranged for raising the shaft so that the arms will not become imbedded in the thick material if the power should be shut off for any length of time. The shaft can be lowered again gradually while running.

The thickener has been operated at speeds ranging from one revolution in two minutes to one revolution in

forty minutes, depending upon the nature of the solids to be settled out. The power required varies with the size of tank, but for mechanisms to be operated in tanks up to 40 ft. in diameter ½ hp. can be allowed for each machine when driving several from one line shaft.

Normal operation of the thickener causes no wear except on the worm, and many machines are operating to-day that have not cost a cent for repairs in several years. The attendance required varies with the regularity of the conditions maintained and is usually confined to lubrication two or three times per twenty-four hours.

FIG. 2—AGITATOR

The illustration of the agitator (Fig. 2) will give a good idea of the machine, which is very much like the thickener, the central shaft being replaced by a pipe at the top of which distributing launders are arranged so as to distribute the material as it is raised through the pipe by means of air, the solids as they reach the bottom being raked to the center by the arms as in the thickener. The arms are arranged so that they can be raised, in which position the machine is easily started after a shutdown.

From a theoretical viewpoint the use of air in agitating caustic soda solution would be detrimental because of the possibility of reverting the caustic to carbonate, due to the CO_2 content. No data is at hand on this point, but men, both technical and practical, who are actually engaged in making large amounts of caustic soda solution, have been consulted and the consensus of opinion is that the small amount of air required, 6 to 10 cu. ft. per minute at 15 lb. pressure, would not produce a noticeable effect in practice.

The installation for a scheme such as proposed here would consist of a series of possibly two or three agitators and three or four thickeners for washing the lime mud. Referring to the flow sheet shown in Fig. 3, lime and soda ash sufficient for twenty-four hours' operation are to be reduced to ¼ in. and smaller and stored in the hoppers. Crushing becomes necessary in order to insure against the presence of unslackable lime in large lumps to cause trouble in the agitating and washing system. However, the operation could be cheaply effected while filling the hoppers each day by means of suitable crushers.

From the hoppers the lime and soda ash would be fed continuously and in the desired proportion to the first agitator of the series, either with an endless belt with

hopper-gate control or by other suitable devices, many of which are on the market. Weak solution from the washing system would be transferred directly to this agitator as indicated.

A series of agitators are advisable because it reduces the possibility of "short-circuiting," that is, the escape of lime or soda ash from the agitating system before they have had time to react. The size of the agitators in such a system is a function of the time required for the reaction to come to an end or, in other words, reach chemical equilibrium. Sufficient capacity would be necessary to allow the required time.

The heat necessary to maintain the desired temperature would be best supplied by steam coils in each agitator.

The mixture would gravitate between the agitators and finally to the first of the series of thickeners "X."

Overflowing from thickener X would be the clear caustic solution for storage and use. The lime mud as it settles out would be discharged and transferred to the succeeding thickener Y by means of a pump, being thoroughly mixed with the wash liquor flowing from thickener Z in the feed launder before entering the tank. The overflow from thickener Y, as previously mentioned, would be transferred directly to the first agitator and the lime mud discharged and transferred to thickener Z. Wash water would be introduced into the feed launder of this last thickener and mixed thoroughly with the lime mud which would be discharged from this last machine with a very low caustic soda content.

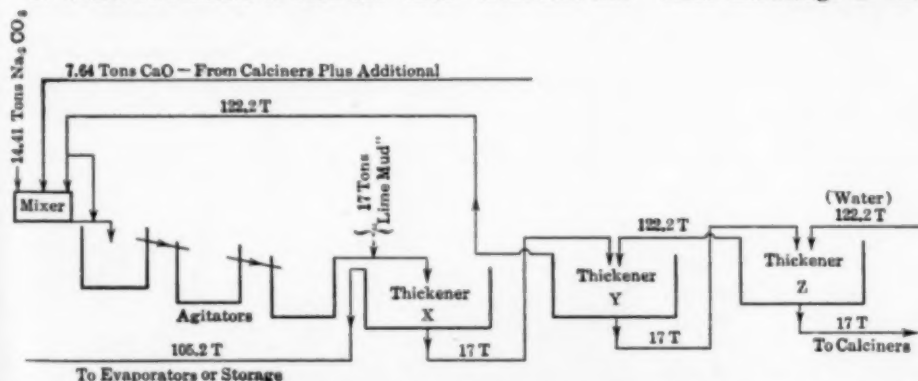It would be feasible to feed the "mud" from this last

FIG. 3—FLOWSHEET OF PROPOSED PROCESS OF MANUFACTURE OF CAUSTIC SODA FROM SODA ASH AND LIME, USING CONTINUOUS AGITATION AND CONTINUOUS COUNTER CURRENT WASHING

thickener to a continuous dewatering filter and thence to calciners, so that the carbonate of lime will be reduced to calcium oxide and may be returned to the causticizing system for reuse.

The objects to be attained by continuous counter current washing are the dissolution under most favorable conditions of a portion of the solids treated, the separation of a solution from a finely divided solid with minimum dilution or both. It would appear that both would be expected in connection with causticizing.

Worthy of notice in such a system is the possibility of the reversible reaction involved coming to equilibrium under the most favorable conditions. It would reach this point in exactly the amount of water that goes to storage from the system as strong liquor. The washing, as will be noticed from the flowsheet in Fig. 3, yields absolutely no weak liquor, with accompanying dilution, to be added to the storage solution.

The following calculations show the results that may be expected by washing the lime mud in such a system as the one proposed. They are made along lines which have found wide favor in metallurgical work because

they have given results which compare very closely with those obtained in actual practice.

T = Tons of water.

Conditions Assumed:

1. Ten tons NaOH produced in twenty-four hours.
2. Overflow from thickener "X" to have approximate Sp. Gr. 1.1 (190 lb. per ton).
3. Yield of NaOH, 92 per cent of theoretical.
4. Sufficient time of agitation to complete reaction.
5. Lime mud discharged from all thickeners with approximately 1 part water to 1 part lime mud.

Let X, Y and Z equal tons dissolved NaOH per ton water in respective thickeners.

Equating values *out* and *in* of each thickener:

1. $105.2 X + 17 X = 122.2 Y + 10$ tons.
2. $122.2 Y + 17 Y = 17 X + 122.2 Z$.
3. $122.2 Z + 17 Z = 17 Y$.

Then $X = 7.32$ $Y = 0.0948$ ton $= 189.6$ lb. per ton.

$\qquad Y = 8.2$ $Z = 0.0129$ ton $= 25.8$ lb. per ton.

$\qquad Z = 0.00158$ ton $\qquad = 3.16$ lb. per ton.

From the above the following results are deduced:

Liquor going to evaporators or storage contains 9.974 tons NaOH.

$\qquad$ = 189.6 lb. NaOH per ton water.

$\qquad$ = 8.68 per cent.

$\qquad$ = 94.8 grams per liter.

$\qquad$ = 13.2 deg. Baumé.

Washing efficiency = 99.7 per cent. No data are available now to bear out these figures.

A careful study of continuous counter-current decantation as practised in gold and silver metallurgy, with some knowledge of the operation of the standard type of causticizing plant as used in the soda, pulp and soap industries, leads the author to summarize in favor of an installation described as follows:

1. The personal element, so prevalent in intermittent work with the possibility of attendant losses in charging, agitating, decanting and washing, would be reduced to a minimum.

2. The reaction would proceed under the most favorable conditions for the production of a solution of a given strength, thus insuring the highest possible yield of caustic soda at all times, and the washing would be accomplished with the least possible water.

3. A relatively large amount of caustic solution of uniform strength would be made in a very compact plant. The installation meeting the requirements set forth in Fig. 3 and the accompanying assumed conditions would require a space of 40 ft. square.

4. The power consumption would be very small. Referring again to Fig. 3, 10 hp. delivered to a line shaft would be more than sufficient to run the six machines and the pumps.

5. The labor required would consist of filling the feeding hoppers. The actual attention to the plant beyond this point would consist of oiling the driving mechanisms, and this could be intrusted to a man whose principal duties were elsewhere.

It is interesting to note that the principles set forth here are the same that have largely taken the place of intermittent decantation and filtration methods in the treatment of metalliferous ores during the past few years, and are now finding their way slowly into numerous other fields of industrial work.   R. W. S.

Gas Blowing Engines at the Steelton Plant of the Pennsylvania Steel Company

The advance in the design of blast-furnace blowing equipment during the last five years has been very marked. The directions of progress stand out prominently. First, rotative speeds and piston speeds have been doubled; second, complications in valve gearing have been eliminated, and, third, automatic lubrication has been perfected to such an extent that the cost of attendance and repairs has been materially reduced. All three lines of progress are represented in the two new gas blowing engines which the Mesta Machine Company recently installed at the plant of the Pennsylvania Steel Company in Steelton, Pa. These engines are the largest gas blowing engines ever built in the United States; the gas cylinders are 46 in. in diameter, the
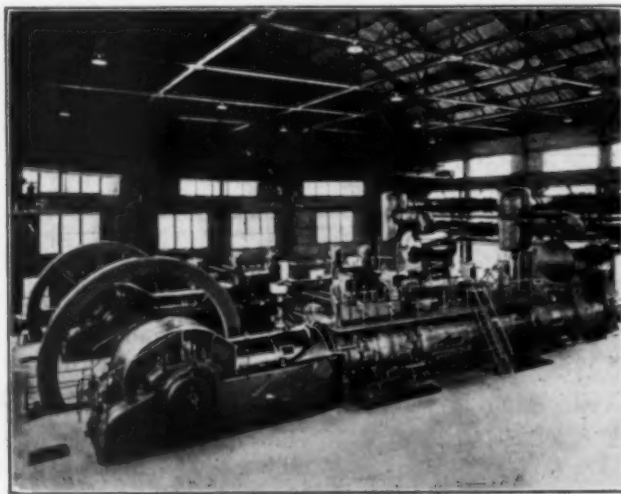

FIG. 1—GENERAL VIEW OF GAS BLOWING ENGINE

air cylinders are 84 in. in diameter and the stroke is 60 in.

As will be seen from the general view, Fig. 1, each of the engines consists of two gas cylinders and one blowing cylinder in tandem. The blowing cylinder is entirely free from valve gearing. The elimination of valve gearing has been made possible by the use of the Mesta automatic plate valves (Iverson patent) which has been so often described and is so well known that no further description is needed here.

The absence of mechanical valve gearing made possible another important step forward; namely, the placing of the blowing cylinder back of the gas cylinder, in contradistinction to previous American practice in which the blowing cylinder was placed on the opposite end of the bed plate and was connected to the main engine crosshead by rods which were arranged to clear the crank and crank pin.

Considered from an engineering standpoint the old American design is wrong. The rods connecting the main crosshead to the blowing piston necessitate a weak crank as well as openings in the bed plate which weaken the latter. Several broken bed plates of gas blowing engines can be traced directly to this design of crosshead, crank and blowing cylinder rods. In the Mesta engines this difficulty does not exist. The position of the blowing cylinder back of the gas cylinder eliminates the rods passing from the crosshead around the crank and leaves the designer free to arrange the bed plate and crank for maximum strength, rigidity and wearing qualities. Furthermore, it made possible the use of a rigid and symmetrical bed-plate construction which is identically the same no matter whether

the engine be used for blowing purposes or for the generation of electric power.

The arrangement of cylinders selected by the Mesta Machine Company is the one which is used on practically all gas blowing engines in Europe. American engineers not familiar with European practice have criticised this design stating that trouble might be experienced on account of unequal expansion of the stationary cylinders and the moving rods, and, that such a long train of cylinders would cause an excessive elastic stretch at the end of the blowing cylinder. Results with the Mesta engines just installed prove that any such fears are groundless. The location of the moving parts compared to the stationary parts was carefully measured
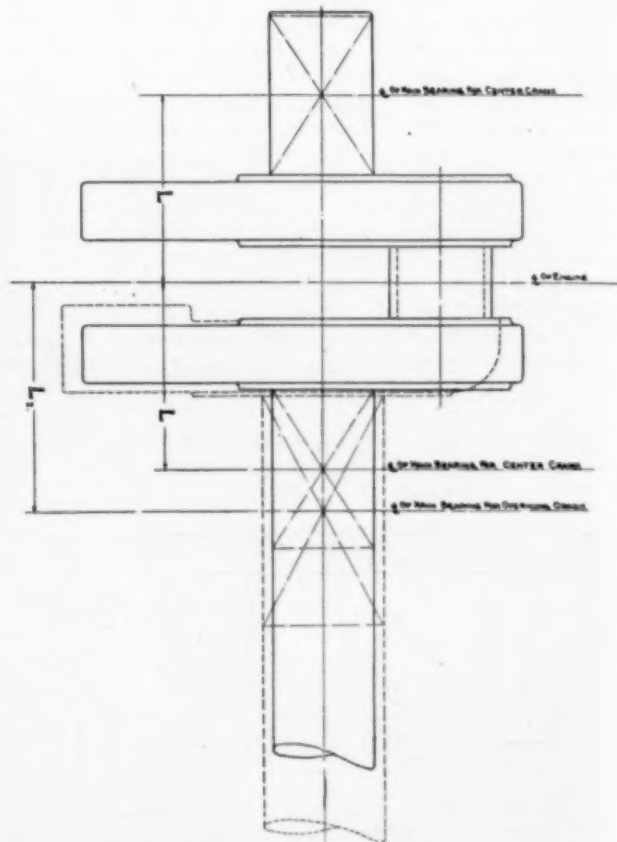

FIG. 2—COMPARISON OF CENTER-CRANK AND SIDE-CRANK CONSTRUCTION

before starting and was again measured immediately after a shutdown following several days operation. The difference in measurement was negligible. Furthermore, the total elastic stretch of the engine measured at the farthest point of the blowing cylinder is imperceptible. A five-cent piece can be balanced on edge in any direction on any stationary part of the engine. In fact, there is less vibration in these engines than is found in ordinary steam blowing engines.

With the Mesta engine the center crank was adopted because its use reduces the bending moment on the shaft to such an extent (compared to the side-crank construction) that a shaft of smaller diameter can be used and yet an engine with a much greater factor of safety results than would be possible with a side-crank construction. In order to illustrate this fact Fig. 2 was prepared in which is shown in full lines the present crank shaft of the Mesta engine and in dotted lines a side crank shaft designed with the same factor of safety. It is evident that the use of the center crank provides a more rigid and safer bed-plate construction with the same weight. In the center-crank design the

characteristic side strains found in the side-crank design are practically eliminated. While the total weights of the center crank shaft and of the side crank shaft are approximately the same, the center crank shaft is of smaller diameter, thus making a smaller opening in the bed plate and making it stronger.

The center crank eliminates one of the most objec-. tionable features of the present-day American gas engine, namely the one-piece design of crank and crank pin. In the one-piece design of the side crank, the pin is cast integral with the crank and must therefore be of a more open-grained or spongy material than a forged crank pin. The builders of large steam engines fought consistently against steel-casting crank pins and would never have consented to the design which was used for about a decade on the gas engine. It is somewhat surprising that American engineers should have held so long to the side-crank constructions in gas engines, when a very simple calculation shows the advantages of the center crank for heavy stresses. In reversing engines for rolling mills where the stresses due to the inertia of reciprocating parts are very great, the center crank has been used for years, and, as already stated, all European gas engines are built with the center crank.

As one of the foremost builders of mill reversing engines in America, the Mesta Machine Company has had considerable experience with center-crank engines, so that it was natural for their engineers to adopt the center crank on large gas engines.

The Mesta engine follows the recent tendency in gas-blowing practice to make blowing engines of the single tandem design rather than to build twin engines. The single tandem engine is preferable from the standpoint
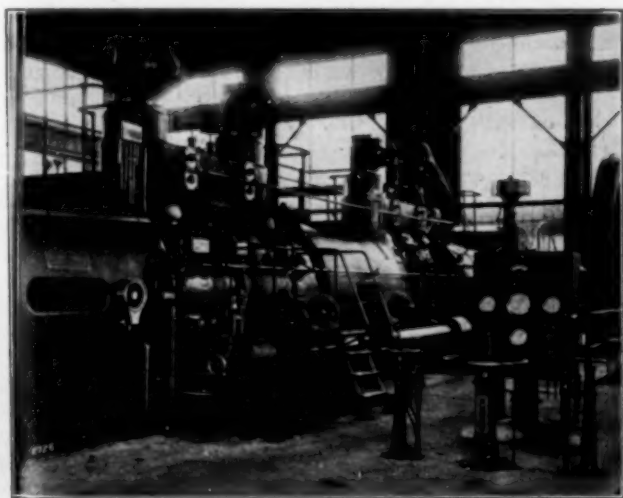

FIG. 3—SWITCHBOARD AND CONTROL HAND-WHEELS FOR GAS BLOWING ENGINES

of first cost and of reducing to a minimum the number of moving parts which require attention. There is only one crank pin and one crosshead and a comparatively small number of valve-gear parts. It is true that each part is larger, but size offers no difficulties in manufacture, so that the single tandem blowing engine will undoubtedly become the standard type.

While heretofore strenuous objection has been made to the gas engine from the standpoint of complication and a multiplicity of moving parts, it can be safely stated that the new gas engine contains a considerably smaller number of moving parts than a cross-compound Corliss engine. Indications are, therefore, that the up-keep and maintenance of this type of engine will be less than that of the cross-compound steam engine.

In the design of the gas cylinders particular attention has been given to the matter of obtaining a sound homogeneous casting absolutely free from strains caused, first, by shrinkage after casting, and, second, by the difference in expansion in service between the outer and inner walls. It was, therefore, decided to make the cylinders in halves of fairly soft close-grained air-furnace cast iron and to securely connect the two halves in the center. By the use of this grade of iron there is less chance for fire cracks to develop than with iron of a harder grade. In order to obtain a good wearing surface, the cylinders were lined with a hard close-grained iron bushing extending over the entire stroke of the piston.

The modern gas blowing engine is just as reliable as the steam engine and, in fact, more reliable. It can be started in less time and does not need to be warmed
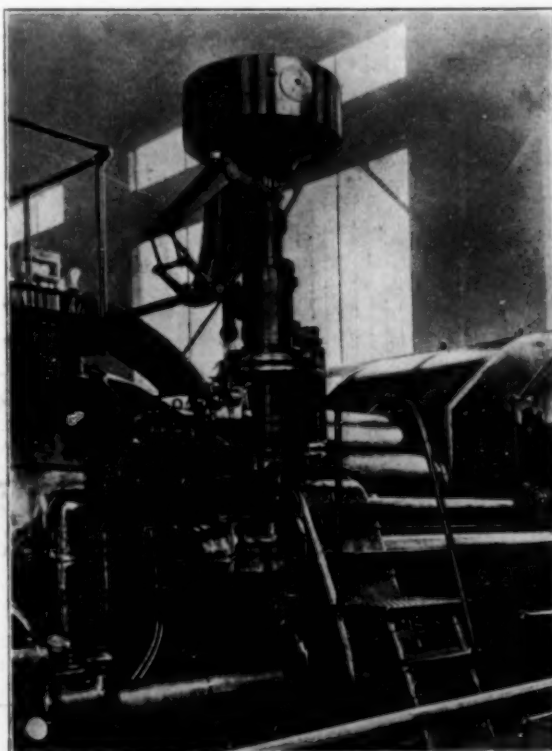

FIG. 4—GOVERNOR AND SPEED-CHANGING DEVICE

up. The Mesta gas blowing engine at the Pennsylvania Steel Company can be started and put on the furnace in less than one minute. This rapidity of handling is made possible by the concentration of all the operating levers and hand wheels on one operating stand.

Fig. 3 shows the switchboard and the control hand wheels. Fig. 4 shows the governor and the speed changing device. When the signal is received from the furnace to slow down the engine, a switch, thrown in at the control stand, changes the tension of the spring in the governor column and thus reduces the speed. As soon as the desired speed is obtained the switch is pulled out. "It beats the throttle all hollow" is the verdict of the operating engineers. The speed-changing device, which is operated by motor drive, is provided with limit switches so that it is impossible for the engineer to exceed the speed-change limit set by the designer of the engine.

Among the minor details contributing toward the success of the engine may be mentioned the exhaust valves which are not water-cooled. The valve seat is cooled and the valve itself can convey enough heat to the valve seat to protect itself. It has been said that a

gas-engine exhaust valve must withstand the action of a red-hot flame passing through it. Theoretical calculations and actual measurements show that the gases passing the exhaust valves are never hotter than 1100 to 1150 deg. Fahr., unless combustion is sluggish during the explosion stroke and continues up to the time when the gases pass through the valve into the exhaust. With a correctly designed engine and ordinary care in operation, combustion is completed before the exhaust valve opens so that water-cooling becomes wholly unnecessary. The operation of the engine at the Pennsylvania Steel Company proves conclusively that water-cooling of the exhaust valve in a properly designed blast-furnace gas engine is a needless complication. It is easily seen that the elimination of water-cooling of the moving valve does away with parts which have previously given trouble in practical operation.

The oiling system for these engines consists of two individual filters, one for each engine, the filters being placed as one unit with one large clean-oil receiver. The
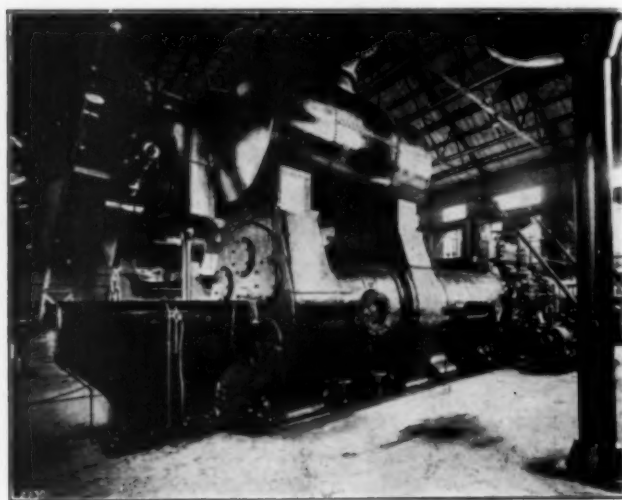

FIG. 5—SNORTING DEVICE AND AUXILIARY CLEARANCE

oil from this receiver is pumped into the system by means of a motor-driven triplex pump running at a very slow speed in order to prevent churning of the oil. This pump delivers the oil to the system at a pressure of 30 lb. per square inch and is equipped with an automatic by-pass which allows the oil to flow back into the clean-oil compartment whenever the pressure exceeds 30 lb. For the purpose of safety there is placed in the system a duplex pump which is connected up to the compressed-air line, also to the steam line, and is controlled by a Foster regulator. If anything should happen to the motor-driven pump and the pressure in the system thereby drop below 30 lb., the duplex pump will automatically start up and thus maintain a constant oil pressure in the system. The filter unit is made by the Richardson Phenix Company of Milwaukee and is capable of handling 800 gal. of oil per hour.

The lubrication of the crank pin is rather unique, in as much as the pin can be supplied with oil from two independent sources. Under ordinary conditions, oil is fed to the pin through the hollow shaft, and the supply coming from the gravity system is controlled by an extra large sight feed. In case of partial clogging of this regular supply, pressure from the oil pump can be turned directly into the pin through a large pipe, thereby flooding, cleaning and cooling it.

Each end of each cylinder is provided with three igniters of the mechanical make-and-break type. A very simple and effective device is arranged on the end

of the lay shaft for the purpose of advancing or retarding all igniters. Each cylinder has its separate circuit with coils, switch, fuses and tell-tale lamp. The spark coils, as well as the tell-tale lamps and switches, are arranged on the instrument board immediately in front of the starting stand so that the operator can conveniently check the operation of the ignition system. Arrangement is made on the cylinders so that any igniter can easily be removed while the engine is in operation.

The regulating gear of the Mesta engine is exceedingly simple and efficient. Each cylinder end contains plain butterfly valves, one for gas and one for air. These valves are located immediately in front of the main inlet valve and are free to rotate without coming into contact with any rubbing surface that might cause friction. Since the vanes of these valves are very thin, there is no possibility for any impurities in the gas to collect thereon and make them "sticky."

The governor action upon these valves is such as to obtain a combination of quality and quantity regulation which has proved to be the most correct and efficient method of regulating gas engines.

Since the butterfly valves are practically balanced, it is obvious that the resistance to governor control is very small, and that the governor can act directly on the valve gear, without the interposition of an oil-relay with all its complications.

Turning again to the blowing end of the engine, the photograph shows that there is a large receiver on top of each blowing cylinder. This receiver protects the blast line from vibration. From the action of the ordinary speaking tube, it is well known that vibrations sent into a cylindrical tube are transmitted long distances without diminution of the amplitude. To damp the vibrations it is necessary to interpose receivers in the line. The closer these receivers are to the place where the vibrations are produced, the better it is for the pipe line. On the Mesta engines, there are two receivers in series close to the engine, one receiver directly on the blowing cylinder and the other a short distance away. The last-mentioned receiver acts as a distributor for the two blast lines.

For ease of handling of the engine two additional devices are of importance; namely, that for the variation of clearance space and the snorting device. Blowing engines for blast furnace service, as is well known, are subjected to peculiar conditions, as the blast pressure may at times rise to 50 per cent above its normal value. If the blowing end and gas end are properly proportioned for the average conditions the gas end is too small for the emergency condition. The Mesta Machine Company has overcome this trouble by a combination of a snorting device and auxiliary clearance. In the bed plate under the blowing cylinder are two Mesta automatic plate valves which in ordinary operation of the engine are kept open by hand-wheel operated screws. The hand wheels will be noticed under the blowing cylinder in Fig. 5.

Furthermore some of the inlet valves at each end are connected to a piston which is controlled by compressed air. Ordinarily these valves operate just like the other inlet valves, but if the small hand lever visible at the outer end of the horizontal diameter of the blowing head is turned 90 deg. the above-mentioned inlet valves are kept open. Keeping open the valve in the inlet duct permits the air to be moved in and out by the piston through the open inlet valves so that there is no air delivered. This device is made use of in starting or in changing stoves, etc. If the valves in the bed plate under the blowing cylinder are closed and the inlet valves are kept open, clearance volume is added.

The effect of clearance, as is well known, is to reduce

the delivery of air and to reduce the mean effective pressure. The reduction of mean effective pressure is made use of, if the blast pressure rises beyond 22 lb. per square inch with poor blast-furnace gas or beyond 25 lb. per square inch with good blast-furnace gas. Depending upon the amount of pressure rise above this critical pressure clearance volume is added either to one or both ends of the blowing piston. The volume of air delivered is maintained by speeding up the engine. The engine is designed for a maximum speed of 85-p.m. and has been run successfully at this speed.

Another point of considerable value to the operator of these engines is the ease with which the changing of air delivery from one blast line to another can be accomplished. In each blast-line connection from the second receiver, mentioned above, there is placed a valve operated by compressed air. These valves are controlled from the operating stand and by means of throwing a small hand lever the changing over from one line to another can be accomplished in a few seconds, whereas in older installations of this kind, it took considerable time and manual labor to make the change.

The Pennsylvania Steel Company has installed Venturi meters both in the gas and in the blast mains so that a check can be kept on the performance of the engine. Arrangements are now being made to calibrate these Venturi meters before they are put into actual service. It is expected that a thorough test for volumetric efficiency, gas consumption, regulation, etc., will be made shortly.

Army and Navy Officers Go to Private Plants

A number of army and navy officers have been permitted to resign from the public service to engage in work for private plants turning out arms and ammunition. Among these have been Lieut.-Col. O. C. Horney, U. S. A., formerly in charge of the Picatinny Arsenal; Major William A. Phillips, U. S. A., formerly in charge at the Sandy Hook Proving Grounds; Naval Constructor William E. Ferguson, U. S. N., and Naval Constructor John E. Otterson, U. S. N.

The resignations were held up several weeks, pending a conclusion as to policy by the Government. So far as the army officers are concerned, Secretary Garrison consented to the withdrawal of his officers on the theory that the safety of the United States might eventually rest upon the adequate development of the country's commercial gun and ammunition factories.

So far as the naval officers are concerned, Secretary Daniels took the position, without the announcement of a policy, that the officers in question had fulfilled agreements to serve at least eight years in the service of the United States, entered into when they began their studies at the Naval Academy. Secretary Daniels has always denied that naval officers, after being educated at the government's expense, have the right to resign.

All the officers are to receive salaries far exceeding those paid by the United States Government. In one case this is as great as five times as much as the Government salary, plus a bonus.

The army officers are to superintend the erection of new plants. Colonel Horney is to be employed by the Aetna Explosives Company. The naval officers are to enter the employ of private shipbuilding plants.

Obituary

Gail Mesereau died on July 14 in Cayuga, N. Y., of cerebral meningitis, superinduced by poisoning by noxious gases. He was a distinguished technologist and a popular chemist. He was born at Cayuga, N. Y.,

Sept. 9, 1879, was educated at Cayuga, Auburn and Syracuse, and graduated from Columbia University in 1903 with the degree of B.S. For two years he was chemist to the Susquehanna Dye and Silk Works at Williamsport, Pa. He was successively silk chemist, consulting chemist to the Panama Canal Commission, chief chemist Standard Oil Co. of New York, and consulting chemist and chemical engineer. At the time of his death he was engaged in the manufacture of explosives. He was at one time president of the Columbia University Chemical Society. Was a member of the Chemist's Club, the American Chemical Society, the Verein Deutscher Chemiker, and other scientific organizations.

Joseph Austin Holmes

Dr. Joseph A. Holmes, Director of the United States Bureau of Mines since its organization five years ago, died in Denver, Col., July 12, aged fifty-five years. While the news of his death will come as a shock and surprise to those who knew nothing of his condition, it was not unexpected by his co-workers and intimate friends. About a year ago he was persuaded to relin-
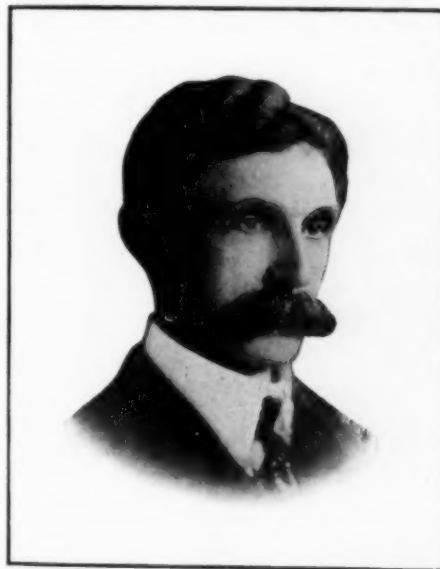
THE LATE JOSEPH A. HOLMES

quish the active direction of the Bureau and go to Fort Bayard, N. M., for a prolonged rest. His recuperation was slow, however, and after a severe setback he was brought to Denver last May.

Joseph A. Holmes was born at Laurens, S. C., in 1859. His early education was received in the South, but later he attended Cornell University, graduating there in 1880. In 1881 he was appointed professor of geology and natural history in the University of North Carolina, remaining there for ten years and continuing for some time thereafter as a special lecturer. For three years following his professorship he was State Geologist of North Carolina. When the St. Louis Exposition was held in 1904 Dr. Holmes was chief of the Department of Mines and Metallurgy. Following this engagement he was placed in charge of the laboratory of the U. S. Geological Survey for testing fuel and structural material, and was later made chief of the technologic branch of the Survey. When the Bureau of Mines was organized in 1910 Dr. Holmes was appointed Director and continued in that position to the time of his death.

All who knew Dr. Holmes were acquainted with his

habits of industry and incessant activity. Personal sacrifice was not considered or allowed to interfere with the numerous duties which he took upon himself. His official travels took him over the entire United States and to Alaska and Panama, and gave him a wider acquaintance among mining men than falls to the lot of most officials. To the end he maintained an active interest in the conservation of life and resources in the mineral industry, and his work to promote the safety and health of others stands as a monument to his memory. Although frequently cautioned to conserve his own health and energy, his friends found it impossible to prevent him from actually sacrificing himself to the cause to which he was devoted. Suffering exposure and undergoing hardships in Alaska and in mines, he contracted tuberculosis, which caused his death. He is survived by his wife, two sons and two daughters.

Technical Section of the American Paper and Pulp Association

A characteristic sign of the times is the formation of the Technical Section of the American Paper and Pulp Association. It has been organized for the consideration of problems affecting cellulose and paper chemistry, machine design, and the various branches of mechanical and chemical engineering which engage the study of paper mill operators.

The executive committee consists of Mr. Henry E. Fletcher (Fletcher Paper Co., Alpena, Mich.), chairman, and Messrs. W. G. MacNaughton (Nekoosa-Edwards Paper Co., Port Edwards, Wis.), and Ernest Mahler (Kimberly-Clark Co., Neenah, Wis.). Mr. Thomas J. Keenan, editor *Paper*, is secretary-treasurer. The committee on publication consists of Messrs. Charles F. Rhodes (International Paper Co., Glen Falls, N. Y.) and Henry Oberman (Hammermill Paper Co., Erie, Pa.).

Personal

Mr. J. V. N. Dorr spent part of the month of July in Colorado and will be in San Francisco in August.

Mr. Frank R. Farnham has joined the staff of Walter B. Snow, Publicity Engineer and Advertising Agent, Boston. Mr. Farnham was previously with the McGraw Publishing Co., in charge of the copy service department.

Mr. N. L Heinz is engaged in designing and erecting the new zinc and acid plant for the American Steel & Wire Co. at Donora, Pa.

Mr. Archibald Jones, who has been general manager for the Bartlesville Zinc Co., Bartlesville, Okla, has been appointed to a similar position with the American Zinc & Chemical Co., at Langeloth, Pa.

Mr. Milo W. Krecji, formerly metallurgist at the Boston & Montana Reduction Works of the Anaconda Copper Mining Co., has been promoted to the position of assistant superintendent. He is succeeded in his former position by Mr. E. S. Bardwell, who has been general foreman of the concentrator.

Prof. Charles E. Locke, of the Massachusetts Institute of Technology, was a recent guest of "Tech" alumni at Denver. After an informal dinner Professor Locke gave an illustrated lecture on the new home of the Institute, which is expected to be occupied in September, 1916.

Mr. W. E. Lummus, of Boston, was in New York and reported great activity in the distillation field.

Mr. J. B. McKennan has been made general man-

ager of the Colorado Fuel & Iron Co., and is succeeded as manager of the Minnequa works by Mr. F. E. Parks.

Mr. H. M. Montgomery, Chairman of the Chicago Section of the American Society of Mechanical Engineers has been elected vice-president and director of the Powdered Coal Engineering & Equipment Co. of Chicago. This company is preparing elaborate plans for the construction and equipment of a large demonstration plant and research laboratory in Chicago where working demonstrations of the adaptation of powdered coal as a fuel to all forms of furnace heat production will be carried on under engineering observation, aided by every influence that scientific research can bring to bear on the production of perfect combustion.

Mr. Irving A. Palmer has been appointed superintendent of the Altoona, Kan., zinc smelter of the U. S. Smelting, Refining & Mining Co.

Dr. William B. Phillips has been elected president of the Faculty of the Colorado School of Mines and will assume the duties of his office Aug. 1. For some years past Dr. Phillips has been engaged as director of the Bureau of Economic Geology and Technology of the University of Texas.

Mr. A. M. Plumb has returned to the Denver office of the American Zinc Ore Separating Co. after a stay of several months at the ore-dressing plant at Plattville, Wis.

Mr. F. W. Sherman has resigned his position as superintendent of the Daly-West mill at Park City, Utah.

Book Review

The Cementation of Iron and Steel. By Dr. Federico Giolitti. Translated from the Italian by Joseph W. Richards and Charles A. Rouiller. Price $4.00 net, New York. McGraw-Hill Book Co.

In seeking for words to describe the place which this book occupies in the literature of the industry one may say that what has been done in the past thirty years for our knowledge of the physical properties of steel by Tschernoff, Sorby, H. H. Campbell, and Howe, has been done for the cementation of steel by Giolitti. The empirical rule of thumb which formerly controlled the processes of cementation and case hardening, Giolitti has converted into scientific formulæ; what reliable information existed previous to his work, he has collected and classified; gaps in our knowledge have been filled by his extensive and skillful researches, and the result has been presented in a book which is comprehensive, legible, lucid and intelligible to anyone with even a foreman's knowledge of the trade. It can be conservatively said that the importance of this work is such that the experienced practitioner might now tell by a study of the efficiency in any cementation plant whether those in authority were, or were not, familiar with Giolitti's book.

The work is divided into two parts, of which the first discusses the chemical and theoretical side of the subject upon which the industry itself is based, while the second part describes the industrial application of the process of cementation and gives those rules and hints for the control and guidance of the process which are most useful to those who are practically engaged in carrying on the operations.

The translation of the book by Richards and Rouiller renders it in a form in which the English-speaking public may secure the result of Giolitti's work without the least difficulty in instant comprehension, or fatigue as a result of continued reading.   B. S.